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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Mechanical Engineering, controlled establishment, Birmingham district. State age, experience and salary required. No person already on Government work will be engaged.—Address, M 590, Offices of Engineering.

Wanted, Chief Draughtsman,

must have first-class experience in design and construction of commercial motor vehicles, also preferred with up-to-date knowledge of factory layout. State age, salary and experience. All applications will be treated in strict confidence. No person resident more than 10 miles from Liverpool Street Station, London, or already engaged on Government work need apply.—Address, M 593, Offices of Engineering.

Wanted, Capable, Skilled,

Working FOREMAN ENGINEER FITTER. Preferably with cement or similar grinding machinery experience; used to large gas engines and electrical generation and transmission; with a preference to doing repairs on the works rather than sending them out to shops, and with some gumption. To live in village near Cambridge. Permanency, if suitable.—Apply by letter, stating age, experience, wages required, when disengaged, married or single, to M 598, Offices of Engineering.

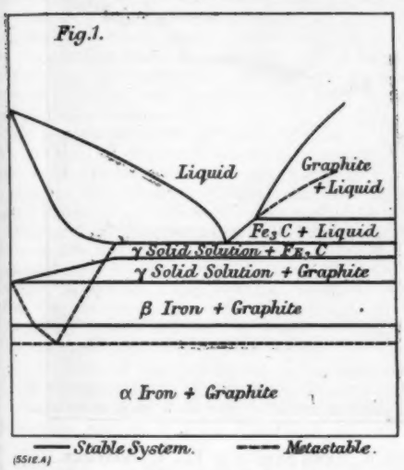
THE FORMATION OF GRAPHITE IN THE IRON-CARBON SERIES OF ALLOYS.

By J. E. HURST.

OF all the series of alloys known to metallurgy, there is probably none to which so much attention has been paid by investigators, as the iron-carbon system. So much so, that the alloys belonging to this series form the basis of a separate branch of metallurgy—ferrous metallurgy.

At the present time, a fairly satisfactory position has been realised with regard to the theoretical interpretation of the phenomenon of hardening and the significance of the Ar2 point in the lower carbon-content members of this series, at least, so far as the industrial application of these alloys is concerned. The same cannot be said regarding the mechanism of the precipitation of free carbon in these alloys, particularly in the higher carbon members of this series. The correct understanding of these phenomena is fundamental to the correct control of the cast and malleable cast-iron industries.

The most widely-accepted theoretical interpretation at the present, of the phenomenon of the precipitation of graphite, is that embodied in the dual conception of a stable and a meta-stable system of equilibria. This conception, and its slight modifications due to Heyn, Charpy, Benediks and others,



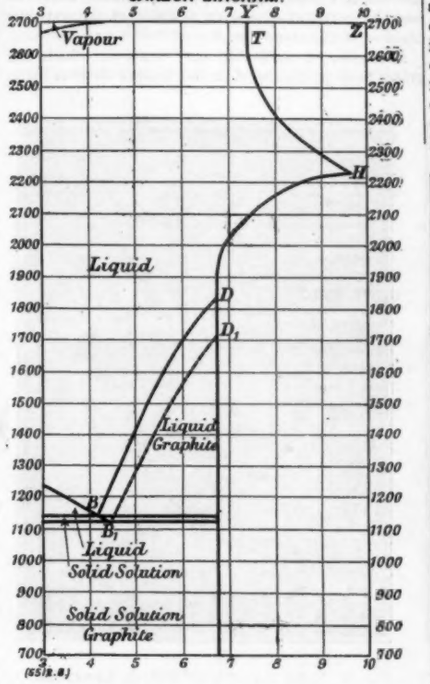
hypothesises a stable system of iron and graphite, and a meta-stable system of iron and cementite or iron carbide. Under ideal conditions, chiefly very prolonged slow cooling, these alloys are assumed to solidify according to the stable system as iron and graphite. The phase in equilibrium with the austenite solid solution separating out from the liquid alloy at the eutectic temperature, would, under these circumstances, be graphite. With comparatively rapid rates of cooling, the system solidifies according to the meta-stable type, and under these conditions, cementite or carbide of iron is the phase separating out along with the Austenite solid solution at the eutectic temperature.

In none of the experimental attempts to retain the stable conditions at the eutectic temperature by the method of rapid quenching of these alloys from this temperature, has the retention of the two phases austenite and graphite, demanded by the stable conception, ever been realised, and in all cases it is found that the phases separating out of the molten alloy are austenite and the carbide cementite. This fact has led to the conclusion by Goerens, Wust and others, that under-cooling always takes place, at least, down to the solidification temperatures and the graphite existing in pig-irons is due to the dissociation of this primarily-formed carbide.

A somewhat different interpretation is placed upon these facts by Gonterman, Edwards, Andrews and others. These investigators assume that cementite is stable down to the eutectic temperature and for a short range below in the solid state down to a temperature closely approximating 1,100 deg. C. (according to Andrews*).

In both these views, considerable difficulty is encountered in the explanation of the familiar occurrence of kish or free graphite, which primarily separates out and rises to the surface of molten alloys containing carbon in excess of the eutectic percentage. To overcome this difficulty, the assumption of an upper limit of stability of the carbide cementite has been made (Fig. 1). According to this assumption, at temperatures and with carbon concentrations but little in excess of those of the eutectic alloy, the cementite carbide is stable and primarily crystallises from the molten liquor, and the break in the liquidus curve at the point would indicate a re-action of the type:

$Fe_3C \gtrless$ graphite and molten liquor, according to whether the alloy is being heated or cooled.



The recent work of Ruff and Goecke and of Hanemann would, however, appear to discredit this conception.

These workers have separately investigated the liquidus curve of the hyper-eutectic alloys. In Ruff and Goecke's experiments, an alloy of eutectic composition was heated to various temperatures up to a maximum of 2,220 deg. C. (as measured by the optical pyrometer). The alloy was maintained in contact with a graphite crucible under a vacuum of 29½ in., and by means of an automatic device, the molten alloys were quenched at the desired temperatures in ice water.

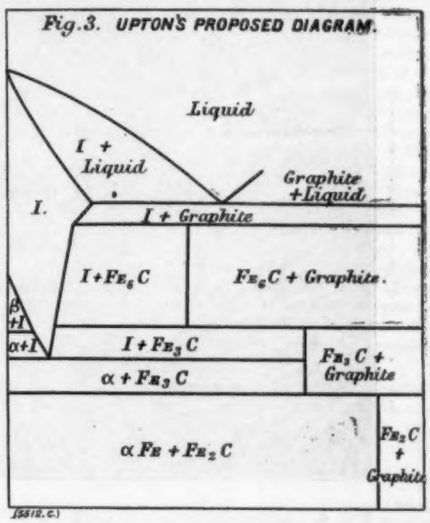
The results obtained by Ruff and Goecke and by Hanemann are plotted in the diagram (Fig. 2). In neither of these investigations has any trace of a break in this solubility curve been recorded, and the work of Ruff and Goecke shows that cementite is the primary phase to crystallise out from these alloys on solidification up to a temperature of 1,850 deg. C., and with a concentration corresponding very nearly to the formula Fe_3C. At this point there is an interruption in the smooth direction of the curve which is attributed by Ruff and Goecke to the instability of the carbide Fe_3C on melting this carbide dissociating into a higher carbide, having the formula Fe_2C according to the reaction

$$2\,Fe_3C + C \gtrless 3\,Fe_2C.$$

Taking into consideration the stupendous experimental difficulties encountered in investigations in this range of the system, the results obtained in both the above-mentioned investigations must be considered to be in close agreement and in both instances the primary precipitation of the carbide in all the hypereutectic alloys up to temperatures and concentrations corresponding to its dissociation is fully confirmed.

It is of extreme importance to note the dissociation of the carbide Fe_3C in contact with the solid carbon at temperatures of 1,850 deg. C. into the carbide Fe_2C, according to Ruff and Goecke's equation.

It is extremely probable that the molten cast iron in the modern hot-blast furnace reaches temperatures well above this figure, and there is every possibility, if equilibrium conditions are obtained, of the formation of this higher carbide in cast iron under these conditions. The formation of kish in such cases would be readily explained on the lines of the above equation. The formation of kish in alloys, in which it is known that the concentrations or temperatures have never exceeded the limit of the Fe_3C range, as shown in Ruff and Goecke's extended diagram, can be perfectly established, a fact which, to all intents and purposes, confirms the meta-stable conception of the system, and that the primary formation of carbide in these alloys is due to under-cooling. This view has been adopted by Ruff and Goecke, who state that on annealing the quenched hyper-eutectic alloys at temperatures at somewhat



above 700 deg. C., the Fe_3C crystals separate slowly into γ iron and graphite. In view of this work, the difficulty of maintaining the stability of the carbide phase for a short range of temperature below the solidification point is, therefore apparent.

Accepting the duplex conception of the system, and in view of the above conclusions, the whole of the graphite, in commercial cast irons, must be considered to be the result of the dissociation of the cementite carbide Fe_3C. In the pure binary alloys it is extremely difficult to determine with exactitude the period at which the graphite is deposited, for, in the majority of cases, the deposition is so slow as to remain undetected by thermal means, and it is only brought about by prolonged slow cooling or annealing. Certain isolated exceptions have been recorded in which practically the whole of the carbon has been precipitated in the graphite form in pig-irons containing such very low silicon contents as to be regarded as practically pure iron carbon alloys.*

Considerable information is gained in this connection from the study of the influence of a third element—silicon. The influence of this element in bringing about the precipitation of free carbon is well known.

The magnitude of the period of the solidification arrest in the iron-carbon-silicon alloys is considered as proof of the precipitation of the free carbon very rapidly upon the solidification of the alloy. It must still be borne in mind that even in high-silicon irons, quenching experiments have shown that the carbide is the phase separating out from the molten alloy

* "Carnegie Memoirs," *Journ. Iron and Steel Inst.*, 1917.

* Adamson, *Proceedings British Foundrymen's Association*: 1916–17; Shaw, Discussion, Adamson's paper, *Journal, Staff. Iron and Steel Inst.*, January, 1918; Foster, *Journal West of Scotland Iron and Steel Institute*, 1910–11.

in equilibrium with the austenite immediately upon solidification.* The assumed reaction by which the decomposition of the carbide is brought about is as follows :—

Fe_3C = C + sol : solution of Fe_3C in Fe.

The carbide decomposes into graphite and the austenite solid solution. The most serious theoretical difficulty introduced by this conception is the application of the above reaction to the dissociation of the carbide precipitated from the saturated austenite solid solution on further cooling along the line SE.

It would appear from practical experience in connection with commercial cast irons, that is, in alloys containing silicon, in normal quantities, say, from 1 per cent. to 2 per cent., the most general type of microstructure observed is one of pearlite and graphite. This observation holds over a wide range of rates of cooling. The microstructures ferrite-pearlite-graphite are also very frequent, but the presence of free carbide and the structures carbide-pearlite-graphite are much rarer occurrences. This points to the fact that normally the whole of the cementite deposited from the saturated austenite on cooling down, must rapidly be dissociated, and it is very difficult to conceive of the reaction Fe_3C = C + Sol solution taking place to completion in the lower ranges of temperature in the neighbourhood of the pearlite point under commercial conditions of cooling. The precipitation of free massive ferrite is likewise difficult to explain in the light of the above equation.

The hypothesis that the austenite solid forms solution and not the cementite, has already been made by Upton†, in addition to a new conception of the system of equilibria of the iron-carbon alloys as a whole.

In the Upton diagram, the duplex conception of the iron-carbon system is avoided, and, in addition, several facts taken from different investigations which have been neglected in previous diagrams, have been embodied. The phases separating out from those alloys, whose concentrations are in excess of those of the saturated solid solutions, are under stable conditions, considered to be austenite solid solution I and graphite (see Fig. 3, page 217.)

On further cooling, at a temperature of 1,095 deg., these react to form a carbide, Fe_3C, which is further transformed in the lower ranges of temperature to Fe_3C and Fe_3C finally.

In the light of this diagram, the structures of white cast irons are due to undercooling, and consist of austenite and undercooled molten liquor. The production of free carbon on annealing is assumed to be due to the completion of the reactions which were suppressed during solidification.

The evidence for the existence of these additional carbides is very small and further work is necessary for their complete identification. At the same time, they are based upon observations made by various investigators, which have not yet been completely explained in any previous conception.

That graphite in cast iron originates from the solid solution rather than from the carbide appears more than likely, and a close examination of the micro-structures of heat-treated white cast irons, certainly appears to confirm this statement. In the examination of heat-treated white irons, whose composition approaches very closely to that of the eutectic composition, it is almost impossible to determine whether the graphite originates from the carbide or the austenite on account of the extreme fineness of the structure.

Likewise, in malleable cast irons in which the graphite is precipitated in the temper carbon form, it is frequently very difficult to decide from which phase the graphite originates.

It seems perfectly legitimate to assume that if the graphite originates from the carbide, it would be found (providing the specimen has not been subjected to prolonged annealing) in close proximity to the original position of the carbide. That this is not the case, is admirably shown in the series of micro-photographs, Figs. 4, 5, 6, of a hyper-eutectic sample of Swedish iron, which has been annealed by rapidly heating to a temperature of 1,000 deg. C. and cooled down slowly in the furnace. The carbide crystals have, in part, decomposed, and close examination fails to reveal the presence of graphite in the proximity of the decomposed carbide. The graphite is to be found in long, thick bands and large round nodules sparsely distributed throughout the specimen. This does not preclude the possibility of the deposition of free carbon in very finely-divided forms, which have been collected together and compressed by the internal strains consequent upon the increased volumes of this new phase graphite into the long thick bands. The conclusion, however, that the graphite has been deposited direct from the solid solution appears more than likely, and the absorption of the carbide by the solid solution as a consequence of its reduced concentration, simultaneously takes place. Otherwise, in such a sample of material, it is legitimate to expect the hyper-eutectic carbide to primarily decompose at a comparatively rapid rate under such treatment.

This hypothesis is certainly more in accordance with the fact that a portion of the graphite is re-absorbed on reheating grey cast irons to temperatures of 900 deg. C. and upwards, forming the solid solution. The possibility of the re-absorption taking place through the intermediate formation of the carbide is very remote, as in the majority of cases, the absorption takes place with such slowness that the formation of the carbide would surely be noticed in quenched specimens.

The hypothesis that the saturated liquid solution, and, in a like manner, the solid solution, is the origin of the free carbon present in cast iron, is an extremely important one.

It appears highly probable that the molecular complexity of the carbide when in solution, is considerably different from that of Fe_3C, and in all probability, the above phenomena are to be explained by the dissociation of the dissolved carbide; phenomena comparable with the dissociation of salts in solution. Of this phenomenon in solid solutions, we have little or no information. Provisionally with the facts at present at our disposal, it would appear that the influence of the temperature of production of pig-iron on the formation of free carbon, is more readily explained on these grounds. In any case it is of considerable importance to note that of the two, graphite is the primary constituent, to form in commercial grey cast irons, and that the ferrite is a later formation, and as a general rule, is deposited round the already-formed graphite plates. The statement so frequently made, "That the graphite is deposited at the side of the ferrite crystal boundaries," is, undoubtedly, not correct.

Fig. 4. Hyper-Eutectic Swedish Iron, showing Carbide Plates. × 150 Diameters.

Fig. 5. Same Sample as Fig. 4, Annealed, showing Partial Decomposition of the Carbide Plates. × 150 Diameters.

Fig. 6. Same Sample as Fig. 4, Unetched, showing Large Graphite Plate. × 75 Diameters.

ALUMINIUM (BAUXITE) DEPOSITS AND THE PRODUCTION OF ALUMINIUM.

(*Concluded from page* 193.)

It is not necessary to mention the manifold uses to which aluminium for years has been put, but attention must be drawn to the vastly increased use which has been made of it during the war in the electrotechnical industry owing to the scarcity, more especially in Germany, of copper. This is readily understood, when one bears in mind that aluminium is very light (2·7 against 8·9 for copper), that it has a very fair conducting capacity (34 against 57 for copper) and relatively satisfactory strength (22 against 44 for copper). In order to obtain the same total conducting capacity, only half the weight of aluminium is required as compared with copper. Compared by weight aluminium may consequently be said to have a conducting capacity twice that of copper. As, however, even the half weight of aluminium has a larger volume than the corresponding quantity of copper, the cooling of an open-air aluminium line is more effective than that of a

* Andrews, *Journal Phys. Chem.*, 1917.
† Upton, *Journal Phys. Chem.*, 1908–12 and 1909–13.

copper line. An aluminium line has also the advantage as regards the stress caused by its own weight, but it is at a disadvantage as regards wind pressure and accumulation of snow.

Pure aluminium has under the microscope a white, slighly fibrous structure, whilst less than 1 per cent. of silicon or iron makes it crystalline and grained, and greyish. Silicon, in otherwise pure aluminium, has not the undesirable mechanical influence of iron, but the aluminium is then liable to corrosion, and its surface is apt to become dark. Sodium has a still worse effect in that direction, for which reason kitchen and other utensils should be made of purest possible aluminium. None of the compounds of aluminium are poisonous, but articles should never be washed with soda; it makes them dark.

Aluminium burns with the development of 7,140 calories, for which reason it has been used for welding, &c., for the reduction of metallic oxides, to produce pure chrome and manganese, &c. Aluminium powder is also used in the manufacture of explosives, for the production of hydrogen, and, with quicksilver, as catalyst in laboratories, for decomposing water. Apart from some minor and less important uses, aluminium is widely employed in the metallurgical industries for its reducing effect on oxides. By its use nitrogen is bound and fixed carbon is transformed to graphite. In order to obtain good results, from $\frac{2}{100}$ per cent. in steel to $\frac{1}{2}$ per cent. in brass, is used. For iron aluminium containing iron can be used; ferro-silicon-aluminium produced direct from bauxite is also used. Aluminium forms valuable alloys, especially with copper, with 8 per cent. to 10 per cent. aluminium.

At high temperatures aluminium quickly loses its mechanical qualities, but aluminium bronze is better in this respect. When aluminium is mixed with copper, the temperature rises, and a chemical compound, Cu_4Al, is supposed to be formed, but the rise in the temperature may also be owing to the aluminium reducing small quantities of oxide of copper ($\frac{1}{2}$ per cent. oxide of copper causes a rise of 200 deg. in the temperature). Aluminium bronze resembles gold, and has a tensile strength of 41 tons per square inch; or with 1 per cent. silicon over 57 tons per square inch. Aluminium with 15 per cent. to 20 per cent. of zinc is said to have a strength of 26 tons per square inch and a specific gravity of 3·2; Duralumin has similar strength and a specific weight of 2·8, and is much used. Tungsten and molybdenum make aluminium elastic.

With regard to the consumption of electric energy in the production of aluminium, Faraday's law requires 2,969 ampere-hours per kilogramme of aluminium, and this result is very nearly (95 per cent. to 90 per cent.) reached in actual production. The voltage necessary for the dissociation of the alumina, according to Thomson, is about 2·8 volts, from which should be deducted the voltage for the formation of carbonic acid or oxide, and added the voltage for overcoming the furnace resistance and for heating the bath. In practice an aggregate voltage of between 6·5 volts and 8·5 volts is employed; if long electrodes are used the voltage will be still higher. In order to produce 1 kg. of aluminium as little as 24 k.w.h. has been employed, but 33 k.w.h. to 35 k.w.h. per kilogramme is considered a satisfactory result. The consumption of alumina is theoretically 1·888 kg. per kilogramme of aluminium, and in practice 1·9 kg. to 1·95 kg. up to 2·0 kg. The consumption of electrodes is theoretically 0·666 kg., or 0·333 kg. per kilogramme of aluminium, depending upon whether carbonic oxide or carbonic acid is formed. When the residue is deducted, the consumption will be found to be below 0·666 kg., so some carbonic acid must have been formed. An electrode consumption of 0·7 kg. to 0·9 kg. per kilogramme of aluminium, with a residue of 0·2 kg. to 0·3 kg., may be looked upon as a satisfactory result.

The following table, which only claims to be approximate and which refers to the conditions prevailing before the war, refers to the cost of production of 1 kg. of aluminium:—

	Francs.
35 k.w.h. at 0·7 centimes	0·25
2 kg. of aluminate at 0·25	0·50
0·8 kg. electrodes at 0·35	0·28
0·12 kg. cryolite at 0·40	0·05
0·05 kg. fluoride at 0·50	0·03
0·25 working hours at 0·60	0·15
Sundries	0·15
	1·35

The Norwegian Höyang Falls Company is erecting an aluminium factory in the Sognefjord of 20,000 h.p. for an annual production of 4,000 tons; their calculations are based on a similar cost of production, viz., 1 kroner per kilogramme of aluminium, a normal selling price of 1·45 kroner being reckoned upon, which should provide a dividend on the share capital of some 15 per cent., the various items in the way of expenses, &c., having been provided for. The share capital is 15,000,000 kroner.

The annual production of aluminium before the war was about 68,000 tons, which was distributed amongst the different countries as under:—

	Per Cent.
United States	33
Canada	8½
Switzerland	17½
Germany, Austria-Hungary	
France	26½
England	11
Norway	2½
Italy	1½

The important factories in the United States are the two at the Niagara Falls, with a capacity of 50,000 h.p., and one at Massena of 100,000 h.p. capacity. In Canada there is a factory at Shawinigan Falls of 60,000-h.p. capacity. These four factories all belong to the Aluminum Company of America.

In France there are factories, with an aggregate capacity of about 100,000 h.p., viz: Société Electrometallurgique Français, with factories at La Praz and at Gardannes; and Compagnie des Produits Chémiques d'Alais, with factories at Calypso, at Felex and at St. Jean de Maurienne.

The Swiss aluminium industry controls factories, with an aggregate capacity of 100,000 h.p., viz., one at Neuhausen, Switzerland one at Rheinfelden, Germany, and one at Lend-Gastein, Austria, also Crippis-Borgne. They are all owned by the Swiss Aluminium Industrie-Aktiengesellschaft.

In the United Kingdom there are two works belonging to the British Aluminium Company and one owned by the Aluminium Corporation.

The countries which have exported most aluminium are France and Switzerland, which two countries prior to the war each exported 7,000 tons to 8,000 tons per annum. Germany has been the largest importer of aluminium, 16,000 tons in 1912 and 12,500 tons in 1913. It is very difficult to obtain reliable information about the production of aluminium during the war; prices have risen abnormally, and new factories have been started which have secured contracts extending over several years after the conclusion of peace.

Provided that the projected factories are built and come into operation, the production of aluminium after the war is likely to be about doubled. If the alumina factories can also double their output, an annual production of some 150,000 tons of aluminium may then be reckoned upon. Of this aggregate 50 per cent. is likely to be produced in the United States and Canada, and 13 per cent. in Switzerland, Germany and Austria-Hungary. The production in Germany, Austria and Hungary has of late been pushed ahead with much energy on account of the war requirements, and several factories are planned and probably in course of construction, in Bavaria (in which the Allgemeine Elektricitäts Gesellschaft is interested), in Austria and Hungary. We may further expect 13 per cent. in France (26½ per cent. before the war), 8 per cent. in England (11 per cent. before the war), 11 per cent. in Norway (2½ per cent. before the war), and 4½ per cent. in Italy (1½ per cent. before the war).

In Norway the following factories and production may be looked for:—

	Tons.
Arendal	5,000
Tyssedal	6,000
Vigeland	2,000
Stangfjord	600
Höyang	4,000

This estimate has recently been made by a French expert, from which fact it would appear, that the French themselves are prepared to lose their leading production of what has been called the French metal. The French, however, have not been idle, but propose to meet the increased foreign competition by starting branch factories in different parts of the world. France is therefore likely to maintain its financial position in the world's aluminium industry for years to come. The French obtained what may be called a privileged position, apart from their bauxite deposits, chiefly through their early developed chemical and electro-chemical aluminium industry, which not only aimed at producing but at finding fresh uses for this new and untried metal.

Since the above list of the Norwegian aluminium works was compiled, at least one more factory has been decided upon.

With reference to the Norwegian aluminium industry it may be stated that the Norwegian Nitride Company was started by the Société Generale des Nitrures through the medium of the Norwegian company for electro-chemical industry, but the latter company no longer has any direct connection with the Nitride Company. According to the original plan the manufacture was to have been based upon Dr. Serpek's patents, but as the experiments connected with them dragged on too long the Nitride Company started an aluminium factory at Eydehavn at Arendal. This factory partly started operations before the war broke out, but the completion of the alumina factory and the electrode factory has been retarded by the war. The Nitride Company, which also is connected with l'Aluminium Française and the Compagnie des Produits Chimiques d'Alais et de la Camarque, has since started a new aluminium factory through the assistance of these French companies at Tyssedal, the material from an American aluminium factory which had not yet been started, being transported to Norway. For the first mentioned factory the Nitride Company hires 25,000 h.p. from the Arendal Water Power Company, and for the new factory at Tyssedal 30,000 h.p. from the Tysse Power Company. The furnaces used are of 15,000 ampere to 20,000 ampere capacity.

The Vennesla Company is the oldest Norwegian aluminium factory of any importance; it is connected with the British Aluminium Company, from which it receives its requirements of purified alumina. The works have their own power station and electrode factory, and use furnaces of 8,000 amperes. The Stangfjord electro-chemical works is a smaller concern, which also has English connections.

The Norwegian Aluminium Company's works at the Höjang Falls has its own power station and has gone in for 10,000 ampere furnaces. The company owns bauxite deposits in France, but is otherwise an entirely Norwegian undertaking.

In Sweden there are, so far, no aluminium works, but like Norway the country possesses a vast amount of unexploited and tolerably cheap water power, which is an essential condition for this industry. Of bauxite deposits, she has none, but there are deposits fairly rich in alumina, which deposits, however, also contain silicon and iron. As it appears very questionable whether a really remunerative aluminium industry can be based on the existing methods used for removing the iron, experiments have been going on in Sweden for the last year or two with another method which, it has been stated in responsible quarters, promises well. The pure oxide of aluminium problem once having been disposed of, the manufacture also of aluminium will no doubt follow in due course.

In Hungary, too, much attention is being bestowed upon the question of exploiting within the country its substantial bauxite deposits. Amongst the concerns interested in the movement is the large Hungarian Natural Gas Company, in which the State of Hungary and some large banks (also the Deutsche Bank) are interested. It is projected to erect aluminium works in the vicinity of the bauxite deposits and to use the natural gas, which will have to be transmitted a distance of 150 km. through pipe lines, as fuel. Pending the realisation of this scheme, the Magyar Bauxite Company, formed in the early part of the war, has been exporting large quantities of bauxite to the Swiss and German works. There are also other schemes

under consideration which would facilitate a Hungarian aluminium industry, notable amongst which the building of a dam on the river Drágán to a height of 60 m., a head of 282 m., and an output of 30,000 h.p., is projected. The power station is planned to be located in the Iadpataker Valley, in the vicinity of the bauxite deposits.

In conclusion we beg to express our indebtedness to Mr. C. F. Röder for his information concerning the Hungarian bauxite deposits and other matters, and more especially to Mr. Oscar Nissen for his very valuable assistance with regard to the aluminium industry generally.

BRITISH ENGINEERING ENTERPRISES IN CHINA.

In a recent article (*vide* page 92 *ante*) we dealt with the causes which have so seriously affected British interests in connection with the development of Chinese railways, and we now propose to consider how our engineering enterprise in other directions in China have been more or less crippled by adverse influences.

Turning first to British mining interests in China, we may say at once that it will be found that prejudice against the introduction of foreign capital, superstition and absurd mining laws have prevented much development of any sort by any nation. Our interests are practically confined to two colliery companies, the Kailan Mining Administration and the Peking Syndicate. The first, of which the old name was the Chinese Engineering and Mining Company, is an Anglo-Belgian-Chinese concern, under British commercial and Belgian technical management. The result of the Belgian element has been that this concern has been of very little benefit to British manufacturers, most of their supplies originating either in Belgium or Germany in pre-war days, but since then the British market has been patronised to the limited extent possible.

The coal output of this exceedingly prosperous concern is nearly 3,000,000 tons annually. Bricks, firebricks, glazed tiles, are also manufactured, and practically all the fireclay sold in China is mined by this company. The company also owns the ice-free port of Chingwangtao. The pits, of which there are nine, are situated at Tongshan, on the Pekin–Mukden line, about 80 miles from Tientsin, and to the discovery of coal here in 1878 the Pekin–Mukden Railway owes its origin; for modern mining was first started here under British management with the idea of supplying the Chinese fleet with an independent source of coal supply. With regard to the Peking Syndicate, this company which has an annual output of nearly 500,000 tons, has its pits situated at Choutso, in the province of Honan, on a branch of the Peking–Hankow Railway. This, again, is an Anglo-Chinese concern, it having been found advisable in both this case and that of the Kailan Mining Administration, to put a stop to local opposition by taking in all the surrounding smaller Chinese concerns. The management of this company is entirely British, and the British capital invested amounts to 1,242,822*l.*

This concern started in 1897 with a capital of 20,000*l.* and acquired the sole right for sixty years to work coal, iron or petroleum in the provinces of Shansi and Shensi. In 1905 it completed the branch line of 90½ miles which connects its mines with the Peking–Hankow Railway. This is a Government railway managed by the Peking Syndicate, who lent China 700,000*l.* for this purpose, a loan since redeemed by the Government. For reasons unknown the company has confined its activities to the neighbourhood of this railway and has never exerted its development rights in other districts. The history of the concern has been somewhat chequered, as it has suffered much from local opposition and in 1912 the mines were so badly flooded that two pits and several thousands of pounds worth of machinery were lost to the company. In addition to the above, there is a small Anglo-Chinese colliery at Mentouko, near Peking, which has an annual output of 80,000 tons. Development has been greatly hindered by the usual ownership disputes.

This is the sum total of our efforts in this direction, a field in which we had a long start. We have held other concessions, but impossible local conditions have entailed their abandonment. As previously stated, the only real mineral development in the country has been done by the Japanese and Germans, who both held railway and mining concessions, and have had very strong diplomatic backing, a handicap from which we have always suffered.

It would be as well here to say something about the extraordinary progress made by Japan in China since the war began. The chronic state of financial shortage in China has been Japan's great opportunity for no other Power has been in a position to lend money since the war broke out. Naturally, Japan has availed herself to the fullest extent of the chance and has lent money freely for a consideration, the consideration taking the form of controlling all the steel and iron ore supplies in the country. As yet she has not worried about railways outside Manchuria, but she controls the Kuikiang–Nanchang Railway, the Hanyehping steel works, collieries, and ore mines near Hankow, and has recently acquired rights, which are still the subject of considerable discussion, over the iron mines in the neighbourhood of Nanking. All the above undertakings are in the Yangtse Valley, generally assumed to be the British sphere of influence. In addition, Japan controls Manchuria, dominates the province of Fukien, and has recently taken over the German rights of exploitation in the province of Shantung, where she now manages all the German railway and mining concerns. The industrial development of China is therefore in Japanese hands, and is likely to remain so, so long as she controls all the known iron supplies; this is not to China's advantage, for she only gets what is available after Japan has been supplied. Japan is daily increasing her hold on China to the detriment, from a trade point of view, of the other Powers, for a dominant Japan in China will mean the stifling of all competition and the shutting of the Open Door, unless Japanese foreign policy undergoes a very radical change. The rise of Japanese power in China is sufficiently indicated when it is stated that she had lent the country previous to 1910 only 247,000*l.*, that this had increased to over 8,000,000*l.* in 1916, and in the past year a further 3,200,000*l.* was added to the total, exclusive of the supposed loan of 4,000,000*l.* for the purchase of arms in Japan, a rather doubtful transaction when it is considered that half the nations of Europe will in a year or two be able to supply China with the very latest engines of war at a very much lower price.

Of other British interests in which the engineering trades are concerned, the only one under Chinese control is the telegraphs, in which we are concerned to the extent of 758,000*l.* These loans are secured on the receipts from the two cables and the inland telegraph receipts. We have no voice in the management of the telegraphs, the majority of the foreign staff, of which there were eight only in 1913, being either Danish or Swedish. The English Marconi Company is also considerably interested in the development of wireless telegraphy, of which there are 13 stations in operation.

Our other interests are confined to the supply of concerns located in the treaty ports of Shanghai, Tientsin and Hankow, and our colony of Hong Kong. These are equipped with all the necessities of civilised life, and as a consequence there is a market for supplying the maintenance needs of the various electric light, tramway and water undertakings. In addition, there is in Hong Kong the Green Island Cement Company, which manufactures the finest cement in the East, as well as a considerable shipbuilding industry, employing some 12,000 hands. In 1917, four ships were built here of about 20,000 tons deadweight, but as the coal comes from North China and the steel from either England or the United States, much expansion in this direction is not to be hoped for until the mineral development of the province of Kwangtung, in which Hong Kong is situated, is undertaken. Shanghai has also its own engineering shops and dock companies, which are capable of building small vessels and doing the ordinary repair work of the coast.

As previously stated, harbour work and river conservancy have received very little attention, but we have practically no voice in the management of what little there is in spite of the enormous preponderance of our shipping on the China Coast, and an experience in this field of engineering greater than that of any other nation. River conservancy is confined to the rivers on which the ports of Shanghai Tientsin and Newchang lie, yet the engineer of the first is a Swede, of the second an Italian, and of the third and least important until lately an Englishman, and now likely to be a Japanese.

Of harbour schemes the only one in hand is the port of Chefoo, which has been given to the Netherlands Harbour Works Company, who lent the Government about 600,000*l.* for the purpose. This company is also agent for a Dutch dredger company, which appears to control the appointment of all engineers required for work of this nature by the Chinese Government, in addition to having a monopoly for the dredger market. The engineer of the national conservancy bureau, a Dutchman, is even said to have been in its employ. In the machinery market we have allowed the Americans, the Germans and the Japanese to oust us. The reasons for this are as follows. It has been customary for the local British merchants to act as agents for British engineering firms, in many cases for many more firms than they could do justice to, even if the sale of machinery were not a secondary business with them. Many large firms finding this naturally unsatisfactory have established agencies with engineers in charge, but this has not proved a success either, for the expense of getting business in China has exceeded that in markets open to us elsewhere. In addition, the representatives sent out, as often as not, have no knowledge of the country or the language, and confine their efforts to the treaty ports instead of travelling occasionally in the interior. Another reason for our lack of success is that we strictly adhere to specifications, dislike the long credit system and the easy, at first sight, contract, in which the customer generally finds that the bill for spare parts exceeds all reasonable expectations, and last, but not least, quote prices in pounds sterling at an English port, f.o.b., instead of a price in Chinese currency delivered in China.

As stated above, previous to the war we hardly found the Chinese market worth while, but those days are gone; and that this market is worth fighting for and will be increasingly so as things develop, the following list showing the value of railway and other engineering material imported in 1914, a year of very little activity in railway construction, is a sufficient indication:—

	Taels.
Manufactured metals, iron, steel, brass, &c.	28,420,632
Electrical fittings	29,785
Machinery, propelling and agricultural	1,000,000
Machinery, weaving	2,035,644
Other machines	4,783,861
Sewing and knitting machines ...	554,265
Chemical products	418,560
Cement	901,241
Needles	545,682
Engine oil	984,728
Railway plant and material, including sleepers	6,500,087
Tools	299,382
Telegraph materials	567,134
Locomotives and tenders... ...	2,514,848
Railway carriages	2,222,999
Other machines, traction engines, motor cars (15 per cent.) and bicycles (60 per cent.) of total...	1,331,939
Total imports from all countries	53,111,637

With the tael at 2*s.* 8½*d.* this amounts to imports of engineering products to at least the value of 7,275,000*l.* annually. It will be noted that more than half the total is for manufactured metals, an indication of the extreme backwardness of this minerally rich country.

This completes the summary of British engineering enterprise in China, and it may be confidently stated that considering that China is more indebted to us than any other nation, our dominating position in shipping, and the great moral obligations of the Government to many individual Englishmen, we do not hold in China the position we ought to, or extract the benefits we have the right to expect.

It would be as well to summarise here this indebtedness, both monetary and moral, as it is perhaps very little realised. The following table

shows approximately the money lent to China by various Powers:—

	£
Great Britain	38,808,000
Germany	22,000,000
France and Belgium	23,740,000
Russia	10,000,000
Japan	8,117,000
Total	102,665,000

With regard to shipping our position was as follows in 1914:—

Percentage Tonnage to each Flag.

Great Britain ...	40·28 or 38½ million tons entered and cleared.
Japan	24·59 or 23½ million tons entered and cleared.
Germany	3·46 or 3 million tons entered and cleared.
France	0·92.
China	25·88.

We therefore contribute to a very large extent to China's revenue, and yet those nations whose flag is seldom or never seen in Eastern waters control the conservancy and harbour schemes of the country.

China's moral debt to Great Britain began in 1863, when General Gordon was lent to the Government to organise the Army and quell the Taiping rebellion, which raged from 1850 to 1864, and is estimated to have cost from 10,000,000 to 20,000,000 lives, in addition to causing incalculable monetary loss. It was also during this rebellion that the reorganisation of the Customs service was undertaken by British subjects, who entered the service of the Chinese Government. This was undertaken at China's request, and it is on the efficient management of this internationally-controlled service that her credit rests. Further, to British obstinacy and enterprise China owes the inception of railways and modern mining.

As regards railways, Sir M. Macdonald Stephenson attempted, in 1863, to get a concession for building a railway from Shanghai to Soochow, now part of the Shanghai–Nanking Railway. This came to nothing, but in 1876 a 2-ft. 6-in. gauge line, 10 miles long, was built between Shanghai and Woosung, the mouth of the Yangtse River. This railway ran for a year, but was purchased in 1877 by the Government, who tore up the line and sent all the materials to Formosa, where they were probably, in part, utilised in the construction of the Formosan railways, of which 11 miles had been built in 1889, under the supervision of a British consulting engineer.

Also, in 1878, coal was discovered at Tongshan and Linsi by Messrs. R. R. Burnett and J. M. Molesworth, and the foundation thus laid for what is now the Peking–Mukden Railway and the Kailan Mining Administration. For out of the transport needs of the mine arose the railway. The coal, in the first place, was transported from the mines over a mule tramway 7 miles long to the Lutai Canal, where it was transhipped into junks for conveyance to the coast. However, by 1881, Mr. Kinder, who had in the meantime become general manager and engineer to the mine, managed to build a locomotive out of the mine scrap heap, and also to persuade the management that nothing very dreadful would happen, but that profit would accrue, if this engine was allowed to replace the mules. This last was a much greater feat than the first, and, of course, the locomotive proved a sound investment, and as nothing talks like money in China, it was only a step further to eliminate the canal altogether, and by 1888 the railway had been completed to Tongku, a small port at the mouth of the Peiho, about 40 miles below Tientsin. By 1898 this railway had been extended west to Peking and east to 40 miles beyond the Great Wall by 1896. Then, in the face of Russian opposition, came the British loan for the Extra-Mural extension completed to Newchang and Hsinminfu in 1904, since which time all progress, with the exception of the extension of the line into Mukden, has ceased, very largely as a result of Japanese opposition.

British engineers of the Peking–Mukden line also constructed the first 100 miles of the Peking–Hankow Railway in 1897–9, so that the Chinese undoubtedly owe all their initial education in railway and mining matters to the British, to whom they are also indebted for the adoption of the 4-ft. 8½-in. gauge, and for the excellent standards of railway construction instituted by us.

From 1897 onwards, Belgian, French, Russian and German capitalists began to turn their attention to Chinese railway development, but ever since then we have taken a greater part than any other nation in this field, and though money has, of course, been made out of our transactions, we have never exploited the Chinese as did the Germans in the construction of their section of the Tientsin–Pukow Railway. In fact, it has often been said that the British in the service of China serve her too well as regards ensuring that she shall buy in the cheapest and best market.

In addition, we played a very considerable part at one time in the reorganisation of the Chinese Navy, and recently have taken the most prominent part in the reorganisation of China's salt revenue. China, therefore, practically owes all her early education in Western matters to us, who imparted the knowledge at considerable risk and great personal inconvenience. She should not be allowed to forget this, nor the power which the money invested in China gives us, and the right to be considered which our great trade confers. China is a country where plain speaking is extremely necessary at times, a fact which our diplomats are either ignorant of or are compelled by certain unknown circumstances to ignore.

Finally, it cannot be too often stated that the regeneration of China must begin with a progressive railway and road policy, that the industrial development is dependent on the efficient management of the railways, the preservation of order, and the introduction of unlimited foreign capital. At present China has a central Government whose power goes no further than the boundaries of the metropolitan province, and her citizens have neither the money nor men of sufficient experience or education for the running of large commercial enterprises. These conditions make the policy of concessions the only one to pursue, and we should withhold our financial support until the Government is compelled to adopt it. If we do otherwise, and lend under the old conditions, we are not only retarding the development of the country, but are also not getting what we might for our capital and for the British manufacturer.

Of course, the adoption of the concession policy would entail agreement among the Powers concerned, a thing never before possible, but which the experience of this war may make so. At all costs the Powers must not drift back into the old condition of grab, undercutting, secret agreements, &c., &c., which brought them many times within an ace of war, gave China her opportunities and seriously hindered her development in the bad old days before the war. Should the United States object too strongly to the concession policy, the Powers should at least adopt the joint-loan principle, in which all would participate, with the proviso that the Board of Communications be under foreign influence. Failing this, railways built with foreign money should be administered by foreigners until the loan was repaid, by which time the railways would be fully equipped and a sufficient number of Chinese trained to carry on the work efficiently.

THE NATIONAL PHYSICAL LABORATORY IN 1917–18.

(*Concluded from page* 211.)

Horizontal Projection Apparatus.—The horizontal projection apparatus for producing shadow images, designed in the Laboratory, and made by Messrs. G. Cussons, of Manchester, consists of a pair of centres and a clamp to hold the gauge, a mount for the projecting lens, an arc lamp, a condenser, and a screen, the parts being arranged on a simple optical bench. The lenses have to be selected to give images covering large screens (up to 8 ft. length) and sufficiently free from distortion to allow of measurements within 0·001 in. The screen is generally placed at the proper distance to obtain a magnification of 50 diameters. The machine serves for testing plate gauges such as driving band gauges and also for examining thread form of screws. In the latter case the beam of light has to be "raked" so as to graze either the upper or the lower side of the screw, and this can be done by swivelling the arm, which carries the arc lamp and condenser, about a vertical axis through the lens. Some notes on the use of projection apparatus will presently be given.

Vertical Projection Apparatus.—The machine, illustrated in Figs. 19 to 25, page 222, marks a development of the devices we described last year (vol. civ, page 4) when the machine was still in the model stage. Numerous demands for this type of machine were received, and with the form adopted measurements of the diameter and pitch of screw gauges can be made to as high a degree of accuracy as can be obtained by mechanical means. The method has certainly proved very useful as supplementary to mechanical methods. Whether it will supersede them remains to be seen. Two of the machines have been installed in the Laboratory. The general idea is that a horizontal beam of light from an arc lamp is, by a prism, reflected vertically upward past the screw which is horizontally supported on centres; the shadow image of the screw is projected through a lens, mounted with its axis vertical just above the screw, on to a horizontal plane mirror fixed about 6 ft. above the lens; the image is reflected downward again and received on the horizontal small table or desk in front of which the observer is seated, enabling him to take measurements or to apply thread-form diagrams. Our photograph, Fig. 24, shows the machine as now supplied by the Director of Munition Gauges, A.M. 8 Department, Ministry of Munitions of War, Queen's House, Kingsway, W.C.; the table was removed when the photograph was taken. Details of the construction can be seen in Figs. 19 to 23, and diagram Fig. 25 further explains the general arrangement of the micrometers and slides. The additional diagrams, Figs. 26 to 30, on pages 222 and 223, exemplify the methods by which measurements are conducted.

Figs. 19 and 20 show the apparatus in elevation and plan, Fig. 21 is a vertical section through the vertical post and the second micrometer, and Figs. 22 and 23 are rather explanatory diagrams of the complicated arrangement. The arc lamp, to the left of the machine, which supplies the beam of light, is of special design. The carbons are adjusted by the observer by means of the horizontal rod connected to the bell-crank lever which operates the slides carrying the carbons. The reflector above the lamp (Fig. 19), which consists of a ground glass and a coloured glass, enables the observer to watch the arc itself. The beam is rendered parallel by a condenser; the reflecting prism of 45 deg. is placed in the base of the machine, as Fig. 19 shows. If we look at Fig. 22, we see on the top the reflecting mirror; lower down the holder of the lens (a kinematograph lens) above the centre carrying the gauge under examination. To the left will be also seen another centre which is used for holding gauges of more than 2 in. diameter. Further down will be seen the table (see also Fig. 21), the movement of this table being controlled by the handle shown best in Figs. 19, 20 and 24. Underneath this handle in Fig. 19 will be seen the incline for adjusting the beam of light reflected from the prism to the rake of the threads of the gauge under examination, a roller bearing on the inclined plane being connected to the prism by the lever shown in dotted lines. The two micrometers, to which reference will be made later on, are shown clearly in Figs. 19, 20 and 21.

The body of the machine consists of a bedplate carrying two slides. The lower slide (Fig. 25) moves horizontally in a direction at right angles to the axis of the screw gauge; this motion is controlled by the pair of micrometer screws whose handles project in front. With the help of these screws rapid measurements can be made on the diameters of the screw gauges up to 2 in. in size. In measuring screw diameters the lower slide need not be fed right across by rotating the micrometer screws. The slide is simply moved across, first to one side, and then to the other, and the sum of the micrometer readings gives a measurement of the motion of the slide from one side to the other. The actual movement of the slide is accomplished by a "throw-over" gear, consisting of a weight and a set of levers shown to the right of the machine (Figs. 19 and 20); this motion is steadied by an adjustable oil dash-pot at the rear of the machine, to prevent any jar on the micrometer spindles when they come

SCREW-THREAD PROJECTOR; THE NATIONAL PHYSICAL LABORATORY.

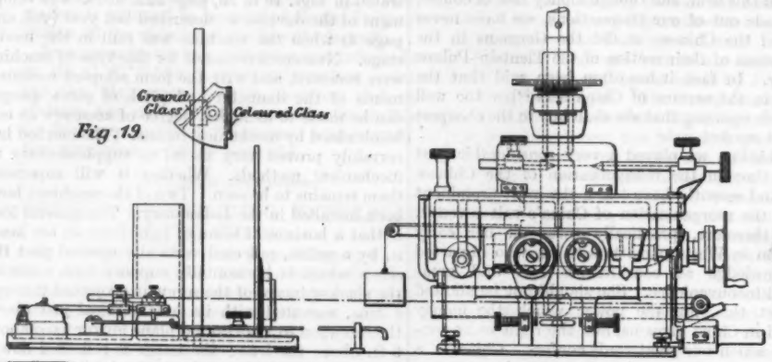


Fig. 19.

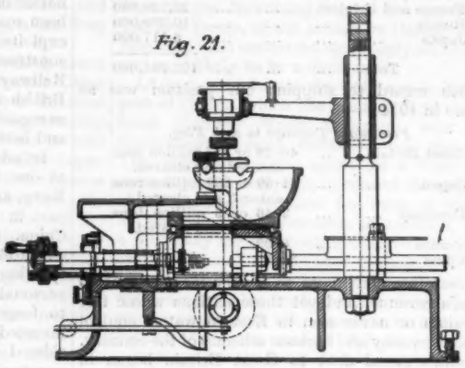


Fig. 21.

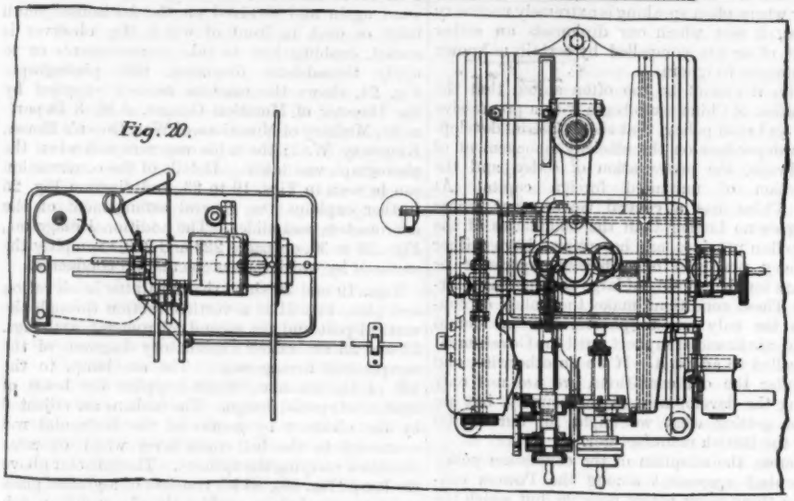


Fig. 20.

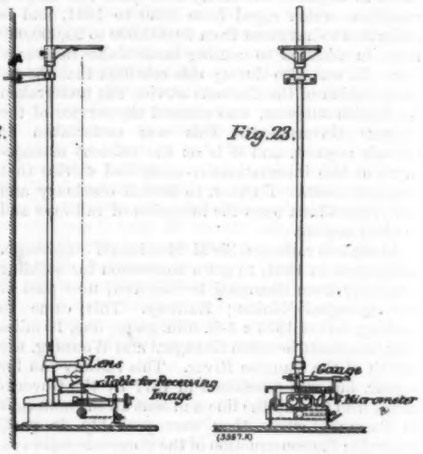


Fig. 22. Fig. 23.

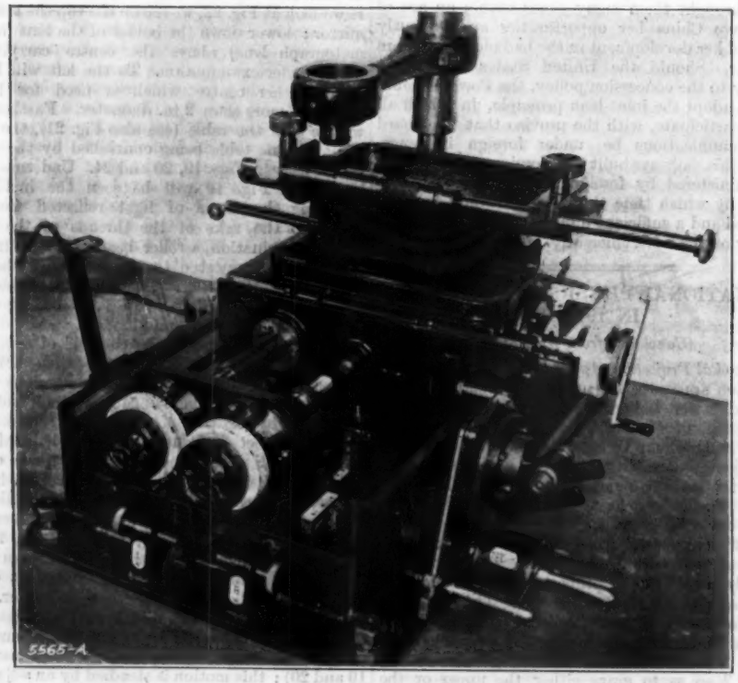


Fig. 24.

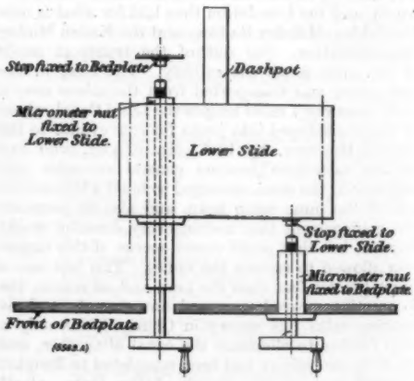
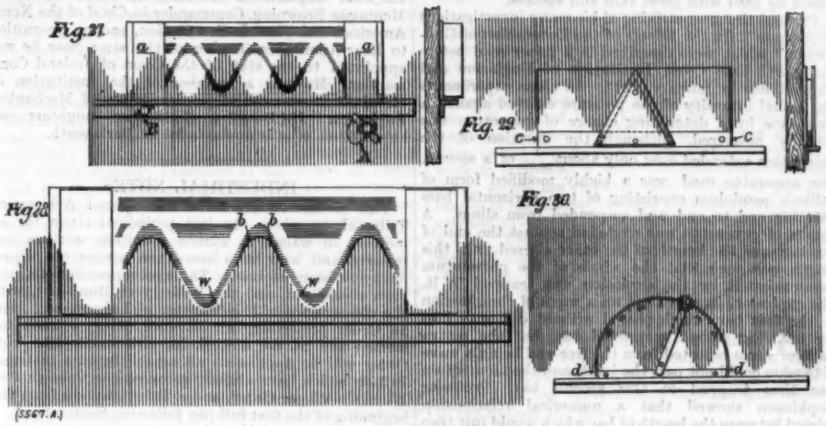


Fig. 25.

Fig. 26.

SCREW-GAUGE MEASURING MACHINES: THE NATIONAL PHYSICAL LABORATORY.



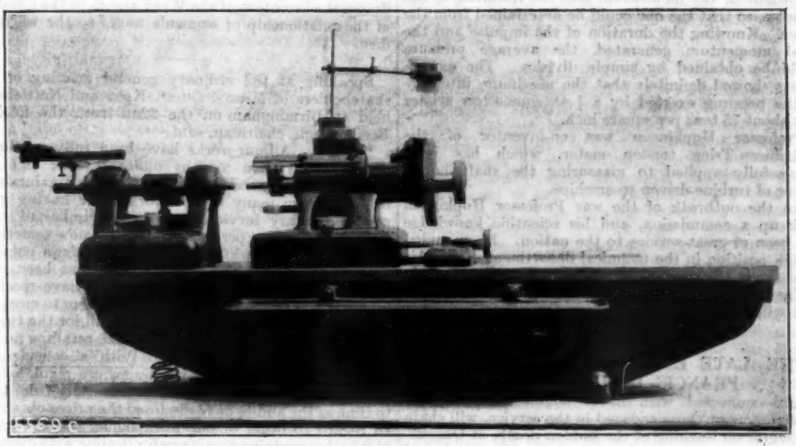


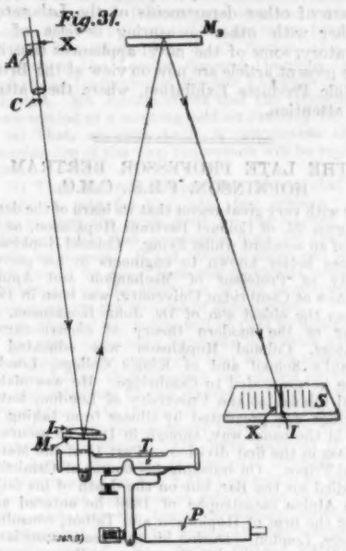
Fig. 32.

in contact with the stops. The second upper slide rests on the lower slide and can move along it in a direction parallel to the axis of the gauge. This movement is controlled by a third micrometer seen on the right of the machine in Figs. 19 and 20. It is by this micrometer that pitch measurements are made, and the pitch-micrometer screw has to be accurately calibrated for the purpose. Errors in the diameter-micrometer are of less importance, since the machine is set up on a plain cylindrical plug of approximately the same diameter as the gauge to be measured. Standard thread-form diagrams, such as Fig. 26 illustrates, are used on this machine, and by their aid errors in the form of the thread, as small as 0·0001 in., can be detected. The magnification used is 50 diameters; this can be adjusted by varying the height of the reflecting mirror.

When used with a horizontal projector, the thread-form diagram should be held against the screen and allowed to rest on an adjustable straight edge fastened to the latter. A screw or an eccentric adjustment is provided at A, Fig. 27, and a pivot or screw at B. The screen itself must be adjustable vertically. The thread shadow should be made to touch the diagram on the full diameter line *a a*, by the aid of the vertical adjustment and of the straight-edge adjustment A. A simple side shift of the diagram on the straight edge will then enable the observer to adjust the diagram as in Fig. 28; the variations from the standard form can thus be observed. The black portions *b b* indicate an excess of metal, the white *w w* portions mark portions where metal is missing from the thread; the overlapping at *b b* can only be seen in a suitably darkened room. As regards actual measurements, it has to be borne in mind that, when the thread-form is mounted on a thick board, the magnification of the image of the gauge will be less on the diagram than on the screen itself. This error may be corrected by moving the projection machine further from the screen, the same distance as the thickness of the diagram used. With 20 ft. distance from lens to screen, $\frac{1}{10}$ in. thickness of the thread-form diagram will reduce the magnification from 50 to 49·98; this error would amount to 0·004 in. on a 10-in. measurement on the screen, and is therefore negligible for ordinary screw-thread inspection.

The thread-form diagram enables the observer clearly to discern all the variations from the standard form, including crests and roots. When only variations in angle, squareness and straightness of flanks are to be studied, a "shadow set square" may be used instead of the thread-form diagram. The straight edge *c c* of this set square (Fig. 29) is made to coincide with the crests of the screw shadow, and the set square is shifted along the adjustable straight edge, until there is only a narrow band of light between the shadow of the thread flanks and the shadow of the set square edge. To obtain measurements of angles in degrees a "shadow protractor," Fig. 30, is used; the screw-gauge shadow appears on the white opaque celluloid face of the protractor and also the shadow of the straight edge *d d* and the edge of the protractor arm. In the thread-form diagrams supplied by the Ministry of Munitions the thread, the full diameter, and the core edges are duplicated, making the snake-like pattern shown in Figs. 27 and 28. The second set of edges and the plain band of the top of the diagram are used for diameter measurements on the special vertical projector for screw gauges and are not required for thread-form examination in the horizontal projector.

Optical Indicator.—The last device with which we have at present to deal is the novel optical indicator



which has been fitted in the Laboratory to Pratt and Whitney end-measuring machines and which is also being applied to other simple types of measuring machines. As supplied by the makers the Pratt and Whitney machine is fitted with a "drop-plug" type of indicator which is quite sensitive to movements of 0·00001 in., but is slow in use. The machine, illustrated in Figs. 31 and 32, was first fitted with the Newall "tilting-level" type of indicator (with bubble), which has the same sensitiveness as the drop-plug, but can be used with fair rapidity; it had, however, its limitations for a certain class of measurements.

A large number of small cylinders were being made for use in measuring the effective diameters of screw gauges, as we previously described, and these cylinders have to be true, round and parallel, within 0·00005 in. In the testing machine the cylinder is rotated while held between the faces, and it was observed that owing to the viscosity of the liquid in the level tube the bubble was sluggish in indicating the slight variations in the size of the cylinder under test, or was apt to overshoot the mark with rapid movement. The optical indicator illustrated was hence added to the level indicator without otherwise altering the latter.

The level tube T (Fig. 31) is tilted through the action of a lever by the displacement of the plunger P of the measuring machine. A small plate-glass mirror M_1 is fixed to T, and a convex long-focus lens L is cemented to the upper surface of the mirror. Above the machine a wall bracket holds the Nernst lamp A which is provided with a condensing lens. The light from this lamp falls on a fine cross-wire C and passes through the lens L on to the mirror M_1, which reflects an image of the wire up to a second mirror M_2, also attached to the wall, and from this latter mirror it is finally reflected on to the horizontal divided screen S, placed behind the machine.

The lens L is required to give a distinct image I of the cross-wire on the screen, this screen being graduated with a scale of which the zero is marked X on the diagram. With the arrangement adopted a movement of 0·35 in. on the screen is produced by a displacement of the plunger P amounting to 0·00001 in., so that a total magnification of 3,500 is obtained by the aid of the lever carrying the level tube and the optical system. Thus the roundness and parallelism of a cylinder can readily be measured within 0·00001 in., and as the indicator is quite dead-beat, the operations can be performed at a much quicker rate than formerly.

In conclusion, we wish to express our indebtedness to the Director of the Laboratory and to the superintendent and the staff of the Metrology Department for the obliging readiness with which they have responded to our requests for information when

heavily overburdened with work. This willingness to assist, we should add, is equally characteristic in the case of other departments of the Laboratory. Together with other measuring devices of the Laboratory, some of the novel appliances described in the present article are now on view at the British Scientific Products Exhibition, where they attract much attention.

THE LATE PROFESSOR BERTRAM HOPKINSON, F.R.S., C.M.G.

It is with very great regret that we learn of the death, on August 26, of Colonel Bertram Hopkinson, as the result of an accident whilst flying. Colonel Hopkinson, who was better known to engineers in his pre-war capacity of Professor of Mechanism and Applied Mechanics at Cambridge University, was born in 1874, and was the eldest son of Dr. John Hopkinson, the founder of the modern theory of electric-current generators. Colonel Hopkinson was educated at St. Paul's School and at King's College, London, whence he proceeded to Cambridge. He was mathematical scholar at the University of London, but at Cambridge was prevented by illness from taking the tripos in the usual way, though in 1896 he secured a first class in the first division of Part II of the Mathematical Tripos. On finishing his course at Cambridge he studied for the Bar, but on the death of his father in the Alpine catastrophe of 1898 he entered as a partner the firm of Hopkinson and Talbot, consulting engineers, London. During his five years' association with this firm he was jointly or personally responsible for the design and carrying out of electric lighting schemes at Crewe, Prestwich and Surbiton, and for the tramway electrifications at Leeds, Newcastle-on-Tyne and Liverpool.

In 1903 the subject of our notice was appointed to the engineering chair at Cambridge. During his career as a practising engineer he contributed papers to *The Electrician* on "The Sag and Strain of Trolley Wires"; "The Losses of Energy in Accumulators"; and on "The Operation of Automatic Circuit Breakers." A paper published in the Proceedings of the Royal Society discussed "The Hunting of Alternating-Current Machines." Some of his best work was, however, contributed to the British Association. He not only submitted papers on the "Parallel Working of Alternators," and on the "Calorimetry of Exhaust Gases from Internal-combustion Engines," but took a prominent part in the proceedings of the Committee on Gaseous Explosions. This committee has done much to elucidate certain anomalies met with in the operation of internal-combustion engines. Just as in the case of the reciprocating steam engine a large portion of feed appears to be missing from the indicator diagram, so also there is a corresponding "missing quantity" in diagrams from internal-combustion engines. The maximum pressure attained is, in fact, only about one-half of the figure calculated from the supply of heat energy and the formerly accepted values of the specific heat of the products of combustion. An hypothesis long popular was that the discrepancy was due to dissociation, but the experiments of the committee proved this view to be untenable. Part of the discrepancy was traced to the fact that the specific heats of the products of combustion increased considerably with rising temperatures, but Hopkinson proved that much of the defect of pressure was to be ascribed to radiation phenomena. As the energy lost by radiation varies as the fourth power of the absolute temperature, the loss to the walls becomes very serious at the temperature of the explosion which may reach 2,000 deg. C. Measurements made in Professor Hopkinson's laboratory showed this loss to be very large, and an explanation was thus afforded of the fact that in practice the use of extremely rich mixtures had been found unprofitable. With such mixtures, in short, the temperature becomes so high that the radiation losses are sufficient materially to lower the efficiency of the engine.

Dr. Hopkinson also helped to clear up another puzzle in gas-engine practice. In Sir Dugald Clerk's early experiments on the explosion of gaseous mixtures, which were made with the gas in a static condition in a closed vessel, an appreciable time was required to effect the explosion. This time was in fact in some cases greater than the total duration of the stroke in motor car engines. There is thus in practice a notable acceleration of the explosion which was traced by Dr. Clerk to the turbulence of the gases consequent on their entry into the cylinder at a high speed, and this view was confirmed by Professor Hopkinson, who found that with a 10 per cent. mixture of coal gas and air in an explosion vessel the time of explosion could be accelerated by stirring up the mixture by means of a fan. Thus with the fan stationary, the time of the explosion was 0·13 seconds, and this was reduced to 0·02 seconds when the fan was run at 4,500 r.p.m. For his gas engine researches, Professor Hopkinson devised a highly accurate and sensitive optical indicator which he used with great skill and success.

Perhaps the most striking of his many investigations were those "On the Effects of the Detonation of Gun-cotton," which were described in a paper read before the North-East Coast Institution of Engineers and Shipbuilders in January, 1914. In these experiments the actual intensity of the pressure exerted against a steel face by a detonating charge of guncotton was actually measured, although the duration of the detonation extended over only about $\frac{1}{50,000}$ of a second. The apparatus used was a highly modified form of ballistic pendulum consisting of two horizontal bars abutting end to end and suspended from slings. A charge of guncotton was exploded against the end of one bar, and the length of the other altered until this length was such that the whole of the momentum communicated by the explosion was trapped in it. The explosion, in short, set up a wave of compression in the first bar, which passed without difficulty into the abutting second suspended bar, but the return wave of stress reflected from the free end being a wave of tension could not pass the joint, and the momentum was thus trapped in this second bar. Professor Hopkinson showed that a numerical relationship existed between the length of bar which would just trap the whole of the momentum and the duration of the impulse, so that the one could be determined from the other. Knowing the duration of the impulse and the total momentum generated, the average pressure could be obtained by simple division. The experiments showed definitely that the maximum intensity of the pressure exerted by a 1-oz. guncotton primer was about 75 tons per square inch.

Professor Hopkinson was co-inventor of the Hokpinson-Tring torsion meter, which has been successfully applied to measuring the shaft horse-power of turbine-driven steamships.

On the outbreak of the war Professor Hopkinson took up a commission, and his scientific knowledge has been of great service to the nation. He occupied a high position in the technical department of the Air Ministry at the time of his death.

The funeral takes place at Cambridge this afternoon, and will be of a military character.

THE LATE ENGINEER REAR-ADMIRAL FRANCIS HENRY LISTER.

All connected with naval engineering, whether constructors or those engaged in the service, will share our regret on learning of the sudden death, at Queenstown, on August 30, of Engineer Rear-Admiral Francis Henry Lister, who was well known in the service and was closely identified with the construction of machinery in the contractors' works, not only for the Navy, but for several of the ships which were ranked as auxiliaries to the Navy, including that for the Mauretania and Lusitania. Admiral Lister was not only an experienced engineer, but a man of sterling merits who had won the respect and regard of his colleagues and of contracting engineers. He had won promotion out of the routine by reason of his merits, and only recently achieved the distinction of being the first engineer officer of his rank to be appointed to the staff of the Commander-in-Chief, Admiral Sir Lewis Bayly, of the Coast of Ireland Command; but unfortunately he has not lived long to enjoy this distinction.

Although he had only reached the age of 56 years, he had already given 39 years to the service of his country in the Navy, having entered as an engineer-student in the Marlborough in 1879; he was at the Royal Naval Engineering College at Keyham until 1885, and was awarded the Newman Memorial prize. After taking the extra professional course at Greenwich Royal Naval College, he served in the Conqueror and Serapis in 1889–90, and for a further year was at the Admiralty. Under Vice-Admiral Sir John Hopkins he was in the Blake when she was a flagship of the North American and West Indies Station. He was instructor in engine design at the Royal Naval College, Greenwich, from 1896–99, and subsequently served as Inspector in the Department of the Engineer-in-Chief of the Fleet for five years, during which, as we have already said, he was closely identified with much of the important constructional work of the fleet. In 1910–11 he served in the Indomitable when she was a flagship of the battle-cruiser squadron, and in the latter year he was appointed Assistant Engineer-in-Chief of the Navy.

In December, 1902, when he was promoted to be Engineer-Captain, he became a member of the Conference on Special Stores, and was lent as Assistant Director to the Priority Section of the Admiralty in 1916. He was the Admiralty engineering representative on various sub-committees of the British Standards Committee and on the Steel Research Committee. Recently he was for a considerable time a useful member of the Shipyard Labour Department under Sir L. Maccassey, K.C. In May, 1917, he was appointed Engineer Captain on the staff of Vice-Admiral Sir Montague Browning, Commander-in-Chief of the North American and West Indies Station, and on promotion to Rear-Admiral in October of the same year he was appointed to the staff of the Coast of Ireland Commander. He was a member of the Institution of Naval Architects and of the Institution of Mechanical Engineers. He leaves a widow, two daughters and an only son, who is now a cadet at Dartmouth.

INDUSTRIAL NOTES.

The recommendations of the Special Arbitration Tribunal, to whom the last periodical claim for an increase in wages to women munition workers was referred and who have heard the parties concerned, have now been received. These recommendations have been considered, and the Ministry of Munitions, with the concurrence of the Minister of Labour, will issue an Order prescribing an advance of 5*s.* a week for women and 2*s.* 6*d.* a week for girls under 18. This Order will be applied to all establishments in Great Britain which have already received the Consolidated Women's Wages Order, and will be effective from the beginning of the first full pay following September 1.

The Minister of Munitions has at the same time drawn the attention of the War Cabinet to the question of the relationship of women's wages to the wages of men.

Speaking at the ordinary general meeting of the shareholders of Messrs. Guest, Keen and Nettlefolds, held at Birmingham on the 22nd inst., the Earl of Bessborough, chairman, said:—

". . . All our works have been fully employed during the twelve months under review, and our outputs have, generally speaking, been well maintained, in spite of so many of our workpeople having gone up for military service. The total number of men, women and young persons employed is now something over 24,000, and while from a shareholder's point of view the result of the year's trading has been of a satisfactory character, those employed have received higher wages or war bonuses to enable them to meet the increased cost of living. Our wages bill for the twelve months is the highest we have yet had, totalling no less a sum than over 3,250,000*l.* With a considerable number of our employees the wages are regulated by sliding scales and have risen automatically from time to time as the audits have disclosed the prices obtained. In regard to other of our workpeople, the Munitions of War Act contains provisions for dealing with disputes as to wages, and in those cases which have been referred for arbitration as between ourselves and our employees the awards have been loyally observed. The wages of colliers have been very considerably increased, involving a greatly enhanced cost per ton of coal. The result is that costs in many instances have attained records, while we as producers have not had a free hand in all cases respecting prices for the materials we have to sell, many of those being fixed by the Government authorities. I mention these facts so that you may understand the conditions under which we have been and are working, and not from any feeling of dissatisfaction with the position which is entirely due to the war.

"With regard to the future, it is impossible for anyone to form an accurate conclusion as to what trade conditions will be after the war. One very important question is that of the supply of iron ore, a subject which has been receiving the close consideration of the Board for some time past. A Departmental Committee was appointed by the Board of Trade to consider the position of the iron and steel trades after the war, and in a report of that committee it is recommended that an organisation should be formed to undertake the import and distribution of foreign ores in Great Britain, and to acquire interests in properties abroad. Already steps have been taken in this direction by some of the leading ironmasters in the kingdom, including ourselves, and a little later we may be called upon to find a considerable amount to acquire such interests, a course which we should not hesitate to adopt if, after full investigation, we considered it was to the advantage of this company to do so. I have dealt with this question of ore, as it is one of the most important factors we have to reckon with. Coal and iron ore are the foundations upon which the whole of this business rests.

"With regard to the position of labour after the war, organisations have been formed with the object of encouraging a thorough understanding between employers and employed, and I am quite sure that anything which can be done in this direction ought not to be put upon one side. A long period must elapse before the havoc which has been wrought during the war will be made good, which means that in all probability workmen will for some time continue to

earn high rates of wages, but what these will be no one can foretell. Should, however, any great difficulties arise between employers and employed, I imagine that the Government will be able to deal with them either by its present machinery for the settlement of disputes and the regulation of wages, or by some extension of it."

A meeting of representatives of the Yorkshire Miners' Association and of the Coalowners with Sir Guy Calthrop, held in London on Thursday, the 22nd inst., led to a rapid settlement of the strike in the Yorkshire coalfields, which had begun on the previous evening. Sir Albert Stanley, President of the Board of Trade, and Sir Guy Calthrop first privately met representatives of the employers. There was a large attendance, and after an hour's conference the proceedings were adjourned till the afternoon. Early in the afternoon the Coal Controller met at the offices of his department the representatives of the men. Mr. Herbert Smith, President of the Yorkshire Miners' Federation, headed the deputation, and presented the miners' side of the case. Further discussion followed, and at six o'clock a settlement was reached, and the following official announcement was made:—

"A settlement having been reached in regard to the dispute in the Yorkshire coalfields, all men and boys should return to work at once, including night-shift men to-night (Thursday)."—R. Richardson (South Yorkshire Coalowners' Association), C. B. Crawshaw (West Yorkshire Coalowners' Association), Herbert Smith (Yorkshire Miners' Association), Guy Calthrop (Coal Controller).

The award which occasioned the dispute provided that surface men should work 54 hours. The men claimed that time for meals should be allowed out of this; and on that small point the whole of the miners of Yorkshire were brought out on strike. The settlement requires 51 hours' work instead of 54, or 8½ hours per day, with half an hour off daily for meals.

At a meeting of the Miners' Federation, held at Southport on Thursday, the 22nd inst., Mr. Robert Smillie occupying the chair, the following resolution was passed unanimously:—

"That this conference calls upon all districts to exercise to the full the functions of pit committees upon the lines suggested by the Executive Committee; that mass meetings be organised by the Executive Committee of the Federation to urge the men to make further efforts to increase the output; and that it be left to the executive to take any further steps in this direction they may deem necessary."

In the course of the meeting, a number of grievances were put forward. For example, the food now available was said to be less sustaining than that which could be obtained before the war, the consequence being that the men became sooner exhausted than was formerly the case; it was urged that in regard to the men released from the army to resume work in the collieries, more physically fit men should be released and more expeditiously than now obtained; there also lacked facilities for the men to get coal away rapidly from the working faces to the open.

That the bonus system of rewarding employees for extraordinary output may work disadvantageously at times and that experience and skill, though coupled with years, should not be ignored are among the suggestions of a story of two municipal companies, referred to by *The Iron Age*, New York. It is related that in the shops of one of the concerns a bonus system prevails and that under it the greater strength, endurance and facility of movement pursued by the younger men is reflected in their ability to produce more shells and thereby add more to their wage than can the older machinists. Some of the latter, seeing their juniors—usually men of less skill as well as experience—outdo them in the matter of money received, became dissatisfied and sought employment in another plant. When they made application they were heartily received, and they entered an establishment where the pay is good but where no bonuses exist.

The plant with the bonus system has a high rate of rejections, the loss of which falls on the company. The men have received their bonuses for the faulty as well as for the good shells. In contrast, in the plant where there is no bonus system there is not the same rush to turn out work and the rejections are very few, so few, in fact, as to be a matter of wonder. Frantic production has been lacking, and perhaps there has been less of the driving spirit, but the energy used has been properly and efficiently applied, all making for thoroughness, and naturally a larger percentage of product acceptable to the inspector. It is no secret that in times past—and the same is true to-day in some places—machine tools have been battered to pieces by mistaken haste, crudely applied force and lack of judgment.

It will not do, adds our contemporary, to generalise too broadly from the two cases cited, but the facts are presented for whatever instruction they may convey to those charged with the responsibility of shop management.

A committee to be known as the Officers' Resettlement Committee has been appointed by the Ministry of Labour to advise as to the steps to be taken for the resettlement in civil life of officers, ex-officers and men of similar standing both during the war and on the demobilisation of H.M. Forces and when necessary to interview selected candidates and advise and assist them in the choice of a career. The committee will work in conjunction with the Appointments Department, which has recently been formed as a separate branch of the Ministry to deal with the above questions, and has its offices at Gresham House, Old Broad-street, E.C. 2. The committee will also deal with the employment of disabled officers and will include two representatives of the Ministry of Pensions, which is exercising its functions in regard to the employment of disabled officers through the Appointments Department.

The committee is under the chairmanship of Lord Burnham, and every endeavour has been made to make it fully representative of professional and business life and of the Government departments interested in the welfare of officers.

The secretary of the committee is Mr. Guy Ridley, C.B.E., of the Ministry of Labour, to whom any communications in regard to its work should be addressed.

The Press Bureau has issued a note stating that the Ministry of Pensions finds that in a number of instances discharged disabled men who are eligible for alternative pension have neglected to make application and are continuing to draw disablement pension. The two classes of pension are entirely different. The disablement pension represents the purely medical assessment of the man's disability, no account being taken either of his earnings before the war or of his present earnings. The alternative pension is based on two factors: (1) The man's pre-war earnings, and (2) the average earnings of which he remains capable. If a man can show that his disablement pension and children's allowances (if any), together with what he is still capable of earning, amount to less than his pre-war earnings he may claim an alternative pension and he should make application to the Local War Pensions Committee. If his pre-war earnings were 2*l.* 10*s.* or less a week, his alternative pension will equal his pre-war earnings less the amount he is deemed capable of earning. If the pre-war earnings exceeded 2*l.* 10*s.* and did not exceed 5*l.* a week, half the excess over 2*l.* 10*s.* is taken into account. Pre-war earnings exceeding 5*l.* a week are not considered in fixing the alternative pension; therefore the maximum alternative pension that may be awarded to a man whose earnings before the war were 5*l.* or more per week is 3*l.* 15*s.* The following examples are given to show how these regulations are to be applied:—

(*a*) Where the pre-war earnings were not more than 50*s.* a week:—

	s.	*d.*	
A man now capable of earning	20	0	a week
And before the war earning....	45	0	"
Would receive	45	0	
Less what he is capable of earning	20	0	
Which gives as his alternative pension	25	0	a week

(*b*) Where the pre-war earnings were more than 50*s.* a week:—

	s.	*d.*	
A man now capable of earning	20	0	a week
And before the war earning....	80	0	
Would receive	50	0	
And half the excess of 80*s.* over 50*s.*	15	0	
Which makes	65	0	
Less what he is capable of earning	20	0	
Which gives as his alternative pension	45	0	a week

If a man has lost both arms or both legs or the sight of both eyes, no account will be taken of any amount that he may be able to earn. If a man was an apprentice before the war, or studying for a profession or employment, allowance will be made, in fixing his alternative pension, for what he might have earned at the conclusion of his apprenticeship or education. Wages sheets and other records relating to wages paid during the year ended August 4, 1914, are of great importance in calculating pre-war earnings, and employers are requested to bear this in mind when getting rid of waste paper.

The London 'bus strike has come to an end on an agreement to reopen the question before the Committee on Production. As many mis-statements have been made as to the origin of the dispute, and the behaviour of the women, the following statement as to the actual facts will be of interest. They are taken from a letter to *The Times* from Mr. W. C. Burton, the resident director of the London General Omnibus Company and of the Underground Electric Railways of London, Limited. Mr. Burton states that the following terms were settled at a meeting held on January 13, 1916:—

(*a*) That, as soon as it is practicable after the termination of the war, the women will be replaced by men.

(*b*) That the rate of pay for women shall be the minimum rate for the men they replace, provided always that the work done by the women shall be identical with that previously done by the replaced male employees. If the circumstances are such that this cannot be done, then the particular problem will be brought to the attention of the employees' representatives for the purpose of adjustment.

(*c*) That no war bonus will be paid to women.

No other agreement as to pay of women exists.

In spite of the agreement that women should receive no war bonus, this company has offered no opposition to the reference of the matter to the Committee on Production. As the result of several submissions and awards, which the company have loyally obeyed, the women since March, 1918, have received 1*l.* a week war bonus, the same as was paid to men. After a further hearing on July 2, the Committee on Production decided that the bonus to men should be increased to 25*s.*, and that the bonus to women should remain unaltered at 20*s.* This award also the company have loyally obeyed. Mr. Burton further states that if, as stated in some quarters, the women conductors held a meeting of protest at the end of July this fact was not communicated to the company or to any of the officials. The facts are as follows:—After the Committee on Production rejected the women's claim for the full 25*s.* bonus, the employees' representatives invited the directors, on August 2, to consider the case. The company immediately acknowledged this letter, but as the proposal was one to reopen a national award it was necessary to consult the other employers before giving a final answer. This consultation required a little time, but on August 16 the unions were advised that, while the Company saw no reason to revise so recent an award, they would be willing to meet the unions and hear their views. No answer was returned, but a strike took place on the 17th. At the time they struck the average earnings of the women for the six days' week were 63*s.* (43*s.* wages and 20*s.* bonus). If they work less than a full week their earnings are reduced proportionally.

In accordance with the national agreement in the engineering and foundry trades, the Committee on Production issued one of its periodical awards on July 24, imposing on firms which are members of the Engineering Employers' Federation an advance of 3*s.* 6*d.* per week to men over 18 and 1*s.* 9*d.* per week to boys and apprentices under 18, from the week ending August 10. As provided by the Munitions of War Act, 1917, the Ministry of Munitions is now issuing an Order which applies the provisions of the award to a large number of non-federated firms in the engineering and foundry trades.

The Municipal Employees' Association are demanding an advance of 15*s.* a week all round. The present rates of pay are 25*s.* a week more than on pre-war conditions.

Two large new berths have been constructed at the shipyard of the Northumberland Shipbuilding Company, Howdon. The scheme involved the construction of a new river frontage of piling and the reclamation of the land behind. Full possession of the site was only obtained on April 11, but the work was so well organised that the keel of the first vessel was laid on April 18, and the second keel on July 16. Both vessels will be launched before the end of the year. About 120 men each day and 60 each night were employed, as well as a number of women who acted as ordinary labourers. The berths are 460 ft. in length, constructed of reinforced concrete, and can be used for the building of the heaviest type of vessel. One feature of the equipment is two steel gantries each 60 ft. in height, constructed on pile foundations, which carry electric travelling cranes between the berths. The work involved the excavation of some 20,000 tons of earth, the driving of between 600 and 700 piles of steel and timber, the construction of 300 cub. yards of reinforced concrete and the erection of 300 tons of steelwork.

A partial strike of the women workers on the Tubes took place on Monday last, but there has been a return to work on a promise that the whole question of equal pay for equal work would receive consideration.

THE 300 H.P. MAYBACH AERO-ENGINE.

The appended interesting particulars of the 300 h.p. Maybach engines fitted by the Germans to Rumpler biplanes of the C. 4 type, have been placed at our disposal for publication.

The general distinctive features of the design of the Maybach aero engines are, comparatively speaking, as well known amongst aeronautical engineers in this country as any of the enemy aero engines in service; firstly, by reason of the adoption of the old Wolseley-Maybach aero engines, the design of which was acquired before the war for airship work, and which was based on the design of the original Maybach engine; and, secondly, through the publication of the somewhat incomplete details of construction of the Zeppelin-Maybach engines and their installation, which were collected under great difficulties from the remains of the several Zeppelin airships brought down during the war. These engines, in almost every case, were so badly damaged by fire that it was found almost impossible at the time to compile any really detailed report on their design, or of their power and general performance.

A new and more powerful type of Maybach engine is now being used in service by the enemy, which, according to French reports, develops over 300 h.p., and which possesses great efficiency. During the past few months several of the latest type of Rumpler machines have been captured fitted with the new 300-h.p. Maybach engines. The following report on the design of the 260-h.p. to 300-h.p. Maybach engines is based on a detailed examination of the engine (No. 1,261) taken from a Rumpler two-seater biplane (G. 120), known as the C. 4 type. This machine was brought down in France by a shot which perforated the carburettor and water pump, on January 18, 1918. The machine was, unfortunately, completely destroyed by fire on landing, but the engine was captured intact and little damaged. After slight repairs this engine has been put into running condition and tested for power, consumption, &c., at R.A.E. The results of these tests are given in the following report, together with metallurgical analyses and mechanical tests of materials and alloys used in the principal parts of the engine.

A complete list of the details of the design is given in the various data at the end of this report, including the percentages of weights of all parts, and the results of separate tests carried out on the carburettor and a new design of petrol pump which is used in conjunction with the interesting high-altitude carburettors.

A brief description of the Rumpler C. 4 and C. 5 type aeroplane, in which these new 300-h.p. Maybach engines are fitted, will, no doubt, be of some interest here. Full details of this machine, however, have already been issued in a published report by the Section Technique de L'Aeronautique Militaire. The Rumpler C. 4 machine is a two-seater biplane, corresponding, more or less, to our D.H.4, and is generally fitted with a 260-h.p. Mercedes engine. These machines are designed for long-range artillery reconnaissance and photography and are armed with two guns—one Spandau fixed in front of the pilot's seat, firing through the propeller, and a swivelling gun mounted in the observer's seat behind. A two-bladed air screw is fitted, and a semi-circular honeycomb radiator of unusual design is slung above the engine from the centre section. These machines are generally flown according to report at high altitudes, i.e., from 15,000 ft. to 17,000 ft.—until over the lines, and from the French reports, the new 300-h.p. Maybach engines are more flexible and regular in running than the 260-h.p. Mercedes engines, and are generally preferred by the German pilots.

Compared with the 260-h.p. Mercedes engines fitted in these machines, the new Maybach engines are credited with attaining an increase of 200 r.p.m. at altitudes above 2,000 ft., and also possess greater efficiency in speed and climb in the Rumpler biplanes. Total weight of the Rumpler machine fully loaded is approximately 3,439 lb.

The 300-h.p. Maybach presents several unusual and interesting details, and as compared with the old 240-h.p. Zeppelin-Maybach design, the new engines are undoubtedly a great improvement in general design and efficiency. The quality of the workmanship of every part, including the exterior finish throughout, is exceptionally good, and the working clearances are carried to very fine limits. Compared with any of the types of enemy engines, the workmanship is undoubtedly of a very much more finished nature; every part, nevertheless, shows the usual German characteristics of strength and reliability, combined with standardisation of parts and ease of manufacturing, in preference to the saving of weight.

As will be seen by the general views given in Figs. 1 and 2 on Plate XIX, published with the present issue, and by the line drawings, Figs. 4, 15 and 16, on page 230, the general lay-out of the engine follows the usual German six-cylinder vertical type. The compression ratio is exceptionally high, viz., 5·94 : 1, which necessitates the use of very heavy pistons and connecting rods; in these particulars this engine follows the previous Maybach practice, but the adoption of a cast-iron floating bush in the little end bearing is an interesting development.

Four overhead valves per cylinder are fitted—i.e., two inlet and two exhaust. These are operated by rocker levers mounted on roller bearings in brackets fixed to the cylinder heads, as shown in Fig. 2, plate XIX, and by push rods on each side of the cylinders actuated by separate inlet and exhaust camshafts. The camshafts run in plain bronze bearings in the crank chamber, and are splash lubricated.

Little alteration has been made in the design of the massive crankshaft, which runs on plain white-metal lined bearings throughout, and is provided with the well-known Maybach type centrifugal pressure lubrication system to the crank-pins, thence to the gudgeon pins through small pipes inside the hollow connecting rods.

The three separate and detachable gear oil pumps, which are situated in the bottom of the base chamber, are of new design. The pump driving shaft at the front end is driven through a ratchet gear on the front scavenger pump, apparently with the object of preventing an air lock in the lubrication system in the event of backfiring.

A double-acting, oil-sealed petrol pump of unusual design is now fitted. This is driven off an extension of the main oil pump spindle at the rear end of the base chamber, and works, of course, in conjunction with the two separate carburettors. These are of the well-known Maybach type, and have been only slightly modified; they are attached, as in the Zeppelin engines, to the front and rear cylinder water jackets. A full description of the functions and workings of this interesting type of carburettor is given towards the end of this report.

The well-known Maybach induction type starting gear is fitted, but is slightly modified in design. The whole of the induction system and the oil condensing crank-case ventilating system is an interesting point in the design of this engine, as is also the method of attaching the propeller-hub driving flange on the tapered front end of the camshaft.

Practically no alteration has been made to the general design of the very simple and efficient type of water pump, which delivers directly into the bottom of the rear end carburettor water jacket as in the old Maybach engines. Ignition is by two Z.H.6 type Bosch magnetos, which are driven directly off the rear ends of the camshafts; the position of the sparking plugs in the cylinder heads is a point of interest dealt with in detail in the following description.

Cylinders.—In comparison with the Zeppelin-Maybach engines, the cylinder of the new 300-h.p. Maybach engines are of very much lighter construction; and, as will be seen from the photographs and sectional drawings, are of a wonderfully clean design. Each cylinder shows practically a rectangular view from almost any point of view, with no excrescences or extensions. The whole construction of the cylinders, and particularly the formation of the cylinder head, presents many interesting details of design.

Referring to the sectional drawing, Fig. 10, page 227, it will be seen that each cylinder is built up of a thin steel barrel, machined and ground to 165 mm. bore, and machined on its outer surface to a thickness of 3 mm. The thickness is increased from 3 mm. at the bottom of the water jacket to 4·5 mm. at the cylinder base flange.

Fig. 9. Cylinder Complete.

Into the top of the cylinder barrel is screwed the cylinder head, which is of cast-iron. A detailed sketch of this screwed joint is shown in Fig. 11. The screw thread, it will be noted, is 2·3 mm. pitch, buttress thread. A soft brass washer is fitted at this joint between the cylinder head and the top face of the screwed portion of the cylinder barrel. The bottom of the cylinder barrel extends only 3·5 mm. below the base flange into the registering joint of the crank-case, and the bore of the cylinder is very little chamfered.

The design of the cylinder heads and the formation of the water passages round the twin inlet and exhaust valves is unusual, and the double inlet and outlet water connections between each pair of cylinders are of new design. The sparking plug bosses are somewhat inaccessibly situated in the space between the two cylinder-head water joints, as seen in Fig. 9. The two semi-circular bosses which are cast on the sides of the cylinder water joints are provided for the attachment of the two carburettors, which are fixed to the front and rear cylinders by long studs screwed into these bosses in the water joints. To allow for the interchangeability of the cylinders, these holes are drilled in every cylinder; when the cylinder is not assembled at the front or rear, they are plugged with brass grub screws.

An interesting point of design in these cylinders lies in the fact that no water connections between the cylinders are made other than the twin head joints referred to. (This principle is similar to that used in the cylinders of the Zeppelin-Maybach engines; these were provided with one large water joint, 5 in. diameter, between each pair of water jackets, which was an extension of the cast-iron head. The cylinder barrels were also of cast-iron, and were fitted with two inlet and three exhaust valves per cylinder.)

The exhaust valve pockets are provided with an additional water passage above the exhaust port, and cast so as to give a free water space completely round the centre portion of each exhaust valve-stem guide.

The valve guides cast in the cylinder heads are fitted with cast-iron bushes pressed into position. The exhaust bushes do not extend the full length of the guides as the inlets do, but are kept back a distance of 10 mm. from the bottom of the guide, so that they are protected from the hot gases. As a further precaution against seizing, the diameter of the bottom of the exhaust bush is slightly reduced so that the bush has room to expand.

Contrary to the usual German practice of building up the water jackets of sheet steel acetylene-welded at the joints the water jackets are machined from cylindrical steel forgings, which, as shown in Fig. 11, are screwed on to the flange machined on the cylinder head; the pitch of this thread is 1 mm. This screwed joint is finally sweated in position with soft solder, the whole depth of the screwed portion having apparently been previously tinned; the joint is locked with four 6 mm. grub screws.

The whole of the water jacket is machined both on the inside and also on the outer surface to a thickness of 1 mm. The water jackets extend to 104 mm. from the base of the cylinders, or, roughly, to two-thirds of the total length of the cylinder barrels; but, as will be noted, the water space is exceptionally narrow—i.e., 7 mm. The only water passages from the cylinder head to the annular water space of the water jackets is through the openings or passages cast in the cylinder heads encircling the sparking plug bosses, and situated directly below the twin water connections. The water jacket capacity of one cylinder equals 1,284 C.C.S.

Fig. 11 shows an enlarged view of the lower joint between the cylinder barrel and the water jacket. This joint consists of a soft rubber composition packing ring, compressed in position between two steel rings by a large ring which screws on to the bottom of the water jacket by a fine pitch thread in the manner shown in the section. This joint is, to a certain extent, flexible and allows for the relative expansion between the cylinder barrel and the water jacket. Small drain plugs are provided at the bottom of each cylinder water jacket; these are screwed into bosses welded into the water jackets on the exhaust side. The combustion chamber is circular, but it is slightly recessed below all of the four valve seats, which are all of the same diameter—i.e.,

54 mm. The area of both the inlet and exhaust ports is 30·15 sq. cm. = 4·66 sq. in. The clearance volume of one cylinder = 778·9 cub. cm. = 47·54 cub. in., giving a compression ratio of 5·94 : 1. Short pieces of aluminium tube are fitted over the top ends of the lugs in the cylinder heads forming the valve stem guides. These are shown in Fig. 10, and are apparently provided for lubrication purposes. Thin sheet steel plates are bolted to the inlet and exhaust ports of the cylinder heads to stiffen up the engine.

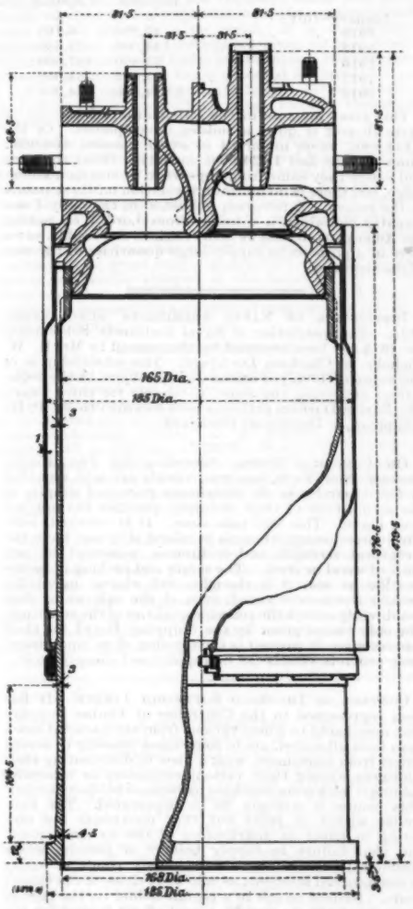


FIG. 10. SECTION OF CYLINDER THROUGH INLET AND EXHAUST VALVES, AND SECTION OF CYLINDER BARREL AND WATER JACKET ON CYLINDER CENTRAL AXIS.

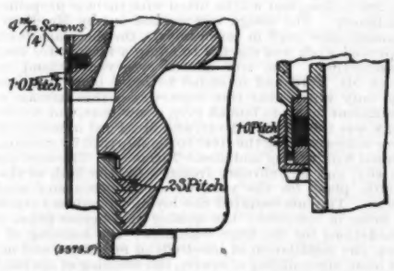


FIG. 11. DETAILS OF CYLINDER HEAD AND WATER JACKET SCREWED JOINTS.

through the piston below the scraper ring in the usual way. The rings are cut diagonally at 45 deg., no locating pegs being fitted; and the width of the ring gap in the cylinder is 1·39 mm. = 0·055 in.

All the piston rings are machine hammered on their inner surfaces. This process which is now extensively used, and is well known, consists of subjecting the inside face of the ring to a series of mechanical hammer blows at gradually increasing distances apart. The process shows a large number of small transverse depressions in the gudgeon-pin bosses, giving a thickness of metal of 14 mm. above and 9 mm. below the gudgeon pin. An oil groove is cut in the piston skirt below the gudgeon pin, evidently to assist the scraper ring and the piston lubrication. The inside of the skirt is machined up as far as the bottom of the gudgeon-pin bosses, and a bevelled lip is turned on the bottom flange of the skirt. The inside of the piston is also machined flat across the head, and down as far as the top of the gudgeon-pin bosses with a 15 mm. radius; an annular rib is cast on

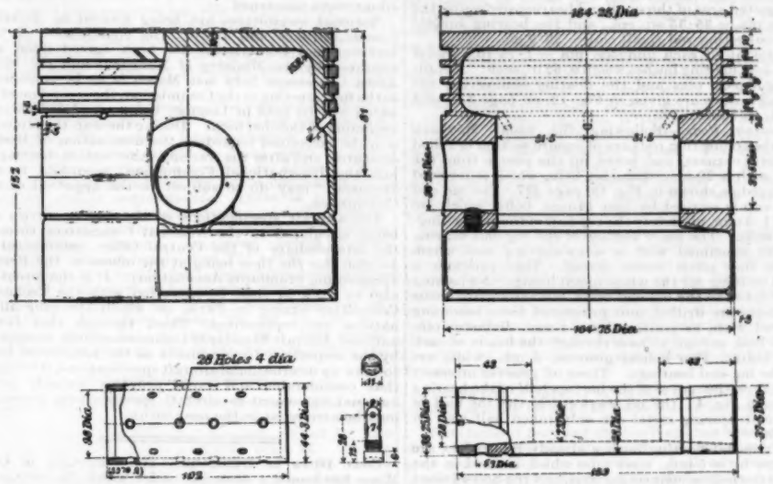


FIG. 12. DETAILS OF PISTONS, GUDGEON-PINS AND FLOATING SMALL-END BUSHES.

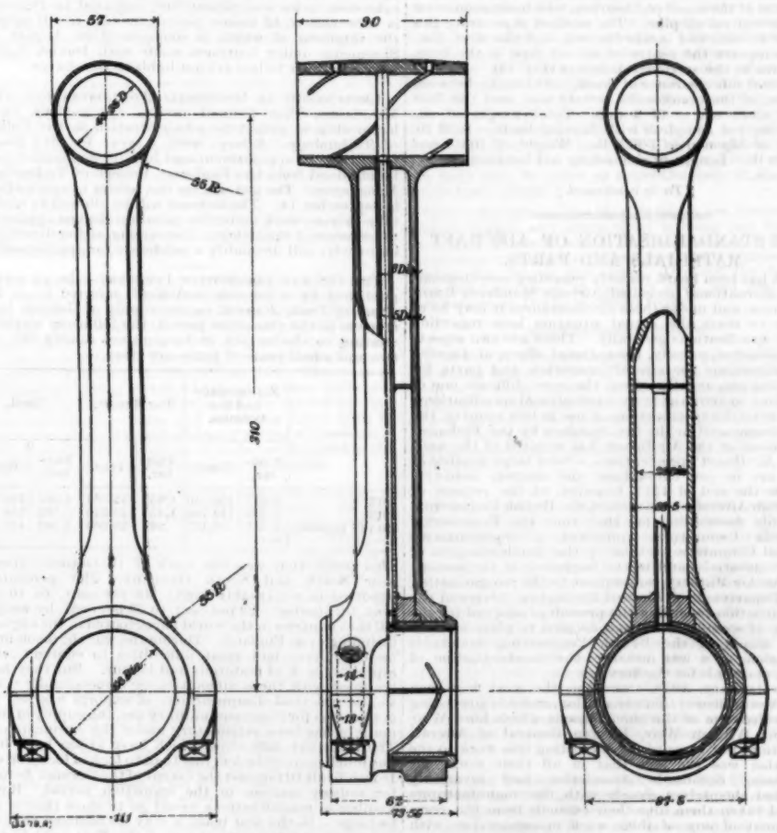


FIG. 13. DETAILS OF CONNECTING RODS.

Pistons.—Very little alteration has been made to the general design of the piston in comparison with the smaller Maybach engines. The pistons are of cast-iron, and weigh 12·3 lb. each, complete with rings. Four rings are fitted all above the gudgeon pin, the lower one being a scraper ring. All the rings are concentric, and are 6·5 mm. wide (vertically) and 5·5 mm. deep, the depth of the ring grooves being 6 mm. The pistons, as will be seen in Fig. 12, are quite flat on both the top and bottom surfaces of the crown, which is 10·5 mm. in thickness. Eight 4 mm. return oil holes are drilled extending nearly the width of the ring on the inner surface. These depressions caused by the hammer are approximately 1 mm. apart at the back portion of the ring—i.e., the part of the ring farthest from the gap—and increase in mathematical progression to about 4 mm. apart towards the front of the ring up to about 1 in., on either side of the gap. This mechanical hammering of the inside ring has the effect of giving the desired uniform pressure to the concentric ring against the cylinder wall.

The holes for the gudgeon pin are bored eccentrically the inside of the skirt to reinforce the gudgeon bosses. Other details of the design of the pistons are given in the sectional drawings, Fig. 12.

Gudgeon Pins.—The gudgeon pins are 159 mm. long, slightly bevelled at the end, and are fixed in position in the piston by a single cheese-headed 9 mm. set screw in the usual way and locked with a split pin. The gudgeon pins are hardened and ground to three parallel outer diameters, being made of smaller diameter at one end than the other. The centre portion which makes the small end bearing is 38 mm. diameter, and the two

ends which fit into the gudgeon-pin bosses are 37·5 mm. and 38·25 mm. diameter respectively. The pins are bored 23 mm. diameter in the centre, tapering to 28 mm. at each end.

Floating small end bushes are now fitted to the gudgeon pin in the connecting rod smaller ends. These floating bushes are made of cast-iron of a very soft nature. The effective bearing length of the floating bushes is 93 mm., and their external diameter is 44·3 mm. For lubrication purposes a number of 4 mm. holes are drilled and countersunk on the outside. The projected area of the small end bearing surface on the gudgeon pin = 35·35 sq. cm., and the bearing surface in the connecting rod small end = 39·9 cm.

The weight of each gudgeon pin = 1·75 lb., whilst the cast-iron floating bushes weigh 0·62 lb. each. Details of the gudgeon pins and the floating connecting rod small end bushes are given in Fig. 12, on page 227, and in Fig. 4, on Plate XIX.

Connecting Rods.—Following the usual Maybach design, the connecting rods are of square section bevelled at the four corners, and bored up the centre from the big end with a 28-mm. diameter hole, which is screwed and plugged as shown in Fig. 13, page 227. The big end bearing cap is secured by four 14-mm. bolts, which are screwed 1·5 mm. pitch into the top half of the connecting-rod big ends. The inner surface of the big-end bearing shells are machined with a screw-cutting tool which leaves a fine pitch screw thread. This provides a serrated bedding for the white-metal lining. No locking nuts are fitted to the big-end bolts, but the square heads of the bolts are drilled, and prevented from becoming unscrewed when in position by a 4-mm. diameter pin, which is long enough to pass through the heads of each pair of bolts. Two helical grooves, 2 mm. wide, are cut in the big-end bearings. These oil grooves intersect each other on the centre of the bottom half of the bearing as shown in Fig. 4; the oil ways cut in the top half of the big-end bearing metal are only taken half way on each side.

The little-end floating bushes already referred to are lubricated by a 5-mm. steel pipe which is fixed in the centre of the hollow connecting rods, and the holes drilled in the floating bushes communicate with helical grooves cut in the small end. An annular groove is cut round the centre of the small end bearing, which communicates with the central oil pipe. The method of securing this oil pipe at each end inside the rod, and the steel disc, which supports the centre of the oil pipe in the bore, are shown in the sectional drawings (Fig. 13).

The total side clearance of the big-end bearing between the sides of the crank-webs = 0·44 mm. and the float of the small end = 11·8 mm. Total weight of the connecting rod complete with floating bush = 8·93 lb. Weight of big end = 5·625 lb. Weight of little end = 3·305 lb. Length of connecting rod between centres = 310 mm.

(To be continued.)

THE STANDARDISATION OF AIRCRAFT MATERIALS AND PARTS.

Much has been heard recently regarding specifications of the International (so-called) Aircraft Standards Board of America, and under these circumstances it may be of interest to state the actual situation here regarding aircraft specifications generally. There are two aspects of the situation, namely, the national efforts at drawing up specifications for aircraft materials and parts for immediate use, and the other, the more difficult one of attempting to arrive at truly international specifications. In regard to the specifications in use in this country, the work, commenced in the first instance by the Technical Department of the Air Board, has resulted in the well-known Air Board Specifications, a very large number of which are in use throughout the aircraft industry. Towards the end of 1917, however, at the request of the British Aircraft Constructors, the British Engineering Standards Association (at that time the Engineering Standards Committee) appointed a representative Sectional Committee to take up the standardisation of aircraft materials, and in the beginning of the present year, the Air Ministry, subsequent to the reorganisation of the Department of Aircraft Production, reviewed the whole situation regarding the procedure adopted for the drafting of specifications, and decided to place entirely in the hands of the British Engineering Standards Association, as a war measure, the standardisation of aircraft materials for the Services.

Since January, 1918, therefore, the work has been under the auspices of that association, and it is interesting to note that one of the chief reasons which Lord Weir (then Sir William Weir, Director-General of Aircraft Production) put forward for entrusting this work to the association was the fact that in all their work the Engineering Standards Association had invariably associated themselves closely with the manufacturers and had taken them into their councils from the commencement of any of their work in connection with British standards for engineering materials.

The Sectional Committee, which is now under the chairmanship of Sir Arthur Duckham, K.C.B., Director-General of Aircraft Production, governs the whole of this work, and has some 60 sub-committees and panels under its jurisdiction engaged in drafting specifications, the work also including the revision of many of the old Air Board specifications. This work is being carried out as a war measure, for the department, and consequently these specifications are not issued to the general public but to the department itself for distribution to manufacturers. The subjects being dealt with cover practically the whole field of materials employed in aircraft production (some 40 British Standard Specifications).

With reference to the more difficult question of arriving at international agreement regarding aircraft specifications generally, it should be widely known that at the request of the Ministry of Munitions, the British Engineering Standards Association has nominated the British Section of the International Aircraft Standards Commission brought into being at the Inter-Allied Aircraft Conference held in London in March last, the opening meeting of which was addressed by the Minister of Munitions, Mr. Winston Churchill. The British National Committee is under the chairmanship of Sir Arthur Duckham, K.C.B., and is fully representative of all interests concerned.

National committees are being formed in America, Canada, France and Italy. The constitution of this International Commission has been agreed upon and approved by the Ministry of Munitions and the Inter-Allied Conference held last March is to be considered as the first meeting of the Commission, the second meeting which will be held in London, being scheduled for the beginning of October next. During the war, the Ministry is to be consulted regarding the nomination of British delegates, and after the war any other nation desiring to join the International Commission, according to the Statutes, "may do so subject to the approval of the Commission."

The aircraft specifications of the five countries are being circulated to the National Committees through the intermediary of the Central Office, established in London (for the time being at the offices of the British Engineering Standards Association). It is the intention also to work in close co-operation with the Technical Committee sitting in Paris, on which the four allied nations are represented. Thus, through this International Aircraft Standards Commission fully recognised by the respective Governments as the authorised body to draw up international aircraft specifications, it is hoped that considerable and rapid progress towards international agreement in aircraft specifications generally may be arrived at in the near future.

Coal Dues in Denmark.—The Controller of Coal Mines has issued a direction under which the charge of 10 kroner per ton, which is at present collected by the agent of H.M. Government in Copenhagen, on all coal, coke-oven coke and patent fuel exported to Denmark is increased to 15 kroner per ton in case of all cargoes the shipment of which is commenced on August 25. Shipments under contracts made with Danish buyers before October 15 last are not liable to the charge.

Lectureship in Industrial Administration.—The Manchester City Council invites applications for a lectureship in industrial administration in the College of Technology. Salary, 600*l.* a year for five years. Conditions of appointment and form of application may be obtained from the Registrar, College of Technology, Manchester. The last day for the receipt of applications is September 14. The lecturer will be allowed to undertake private work under the usual conditions applicable to lecturers of the college. Canvassing, either directly or indirectly, will disqualify a candidate for appointment.

The German Locomotive Industry.—In an article published by a German periodical, referred to in *The Board of Trade Journal*, on the supply of German locomotives in the transition period, the following statistics relating to the output of locomotives during the last two and a-half years of peace are given :—

—	For Germany and her Colonies.		For Export.		Total.	
	Number.	Tons.	Number.	Tons.	Number.	Tons.
1912	2,697	153,110	1,355	42,983	4,062	196,093
1913	2,325	118,786	1,457	40,246	3,782	159,032
1914 (7 months)	1,451	86,137	941	25,963	2,392	112,100

This production was the work of 19 factories spread over North and South Germany. The percentage exported is remarkably high: 33 per cent. to 40 per cent. by number; 22 per cent. to 23 per cent. by weight. All the countries in the world participated in the exports, including even England. During the war the locomotive factories have had great difficulties to contend with, especially lack of materials and labour. But they have grappled with these difficulties very successfully; and as the practical disappearance of exports has left the output free for home and military use, the supply of locomotives has been satisfactory under the circumstances. The transport difficulties which have arisen have been due much more to lack of fuel than to lack of locomotives. It is difficult to forecast the extent of the German demand for railway engines in the transition period. But a number of considerations would go to show that it will be large. In the first place it may be assumed that the territories, particularly those in the East, which were provided by the German authorities with German locomotives will, after the war, continue to demand these in even larger measure. In the second place German locomotives are in such a state as to need extensive repairs, and more rolling-stock will therefore be required. Hence in the first instance there will be a great demand for locomotives, but very soon it will return to normal dimensions. The German locomotive industry thus expects to be busy, but in no wise up to the whole of its capacity, especially as in order to execute war orders many works have been extended. The output of which the industry is capable may now be estimated at over 4,000 engines of a total weight of 200,000 tons per annum.

IMPORTS OF AIRCRAFT.

We have never had very full particulars of the overseas trade in aircraft. The trade and navigation returns do not give the numbers imported or exported, but merely the money value. The value is stated in one item, including "Airplanes, airships, balloons and parts thereof." As an exceptional movement has recently taken place a tabular statement may be of interest.

Aircraft and Parts thereof.

January–July—	Imports. £	Exports. £
1910	37,200	6,160
1913	146,000	23,800
1916	23,800	167,000
1917	71,000	354,000
1918	3,824,000	174,000

This great increase in the importation of aircraft or parts thereof is quite a sudden development. Of the 3,824,000*l.* value imported in seven months, 864,000*l.* came in June and 1,834,000*l.* in July. What they are and where they came from appears to be common knowledge, but there is no official information on these points in the return. A telegram published in the daily Press recently contained a message from Lord Weir asking the Americans to send as many engines as possible, as we were in a position to supply large quantities of the rest of the airplanes.

Institution of Naval Architects' Scholarship, 1918.—The Institution of Naval Architects' Scholarship for 1918 has been awarded by the council to Mr. H. W. Nicholls, of Chatham Dockyard. The scholarship is of the value of 100*l.* per annum, and, subject to the regulations governing the same, is tenable for three years. The Earl of Durham prize has been awarded to Mr. P. H. Knapman, of Devonport Dockyard.

On Concrete Ships.—According to *The Marine Journal*, New York, concrete vessels are still regarded in official circles as an experiment pure and simple, as the actual trial of their enduring qualities has not yet been made. This will take time. It is believed, adds our contemporary, that no moulded ship can have the structural strength and endurance possessed by one built of wood or steel. The strain and racking of severe weather at sea, it is thought, will almost inevitably weaken a concrete vessel, even if the salt water does not directly attack the cohesive qualities of the structure. The only excuse given by the Shipping Board for their construction at present is the meeting of an emergency, since concrete vessels can be rapidly and cheaply built.

Control of Imported Softwood Timber.—It has been represented to the Controller of Timber Supplies that merchants to whom rations from the national stock have been allocated, are in some cases refusing to accept orders from consumers, with a view to distributing their allotment among their various customers or otherwise holding it back from purchase by persons holding permits. This course is strongly to be deprecated. The Controller wishes to point out that merchants are now acting in effect as distributors of the national stock, and that failure to supply holders of permits where unsold rations are available can only result in injury to the national interests, as well as to those of the timber trade. Refusal to sell to a permit holder on the part of a merchant able to supply, would afford ground for the withdrawal of the merchant's ration. In the event of undue delay by the trade in the supply of timber to a customer holding a permit, the Controller might find it necessary to supply direct from the national stock.

Submarine Destroyers.—According to *The American Marine Engineer* the submarine destroyers introduced by Mr. Henry Ford under the name of "Eagle" boats are 200 ft. long and will be fitted with turbine propelling machinery. The design was worked out by Mr. Ford's drawing-office staff in seven days. On the plans being approved work was started to equip a factory for their construction. The site chosen was vacant land on which Mr. Ford had intended to build blast furnaces. The only water near this tract was a thin stream of insufficient depth to launch even a row-boat, but 6 miles away was the Detroit River, and Mr. Ford immediately gave orders to bring the river to his shipyard by dredging a canal 6 miles long and about 7 ft. deep. The land was marshy, and in February frozen. On the 20th of that month, plans for the yard were completed and work began. This necessitated the laying of railroad tracks to bring in material; the sinking of concrete piers, as foundations for the huge buildings; the building of a dock, the installation of hundreds of machines, and not the least, the building of sewers, the draining of the land, and bringing water from more than 2½ miles away, for mixing concrete and other purposes. The first building erected was the fabricating plant, in which the machinery for moulding and punching the plates, and for making and shaping the various other parts of the hull is installed. That building is 150 ft. wide by 450 ft. long. In front of the fabricating plant stands the assembly building, 1,700 ft. long by 300 ft. wide (said to be the largest building in the world), with three tracks running the full length of it, and on each track seven "Eagles" will be assembled simultaneously, making 21 boats under construction at the same time. Beyond the assembly building is the basin, concrete-lined, into which the ships are launched, and leading out from that again, along the canal, are the docks on either side, 1,100 ft. long, from which the boats will be fitted out.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Work of an urgent character continues to occupy the whole attention of steel makers in the West of Scotland—it is war requirements all the time. The manner in which the excessive output is being maintained is nothing short of marvellous, and not until after the war will it be known what a very active share in the great campaign has been borne by the enormous "arsenal" of which Glasgow is the centre. Sectional bars and high tensile steel for shells are a heavy item, but so also are the ship, boiler and tank plates required by the shipbuilders for the constructional work which they have on hand. It is confidently expected that the further powers given to the Metal Controller by the recent Order will result in a considerable tonnage of scrap metal being gathered in, especially as a call is made upon all dormant supplies, old machinery, &c. Where not controlled, prices have a tendency towards stiffening.

Malleable Iron Trade—What is true of the steel trade is true also of the malleable iron trade, and manufacturers are making a very strenuous endeavour to meet the demands put upon them. Everything possible has been done to increase output, and not even the recent advance of price has created the slightest falling-off in the demand from overseas consumers. Their needs are urgent and price has nothing whatever to do with it—although no great supply is available, all that can be spared is speedily shipped to the favoured few. For these consumers, as for those at home, the bulk of the material is required for agricultural purposes, for railway work and mining.

TIN PLATE.—The tin plate market is strong. Works are well booked and buyers are unable to cover the whole of their requirements. Tin is again easier, but it is considered still necessary for the price to be Government controlled. Prices are as follow:—Galvanised sheets, 24G in bundles, nominal; block tin, cash 367*l.*, three months 367*l.*; copper, cash 122*l.*, three months 122*l.*; Spanish lead, 29*l.* 10*s.*; spelter, 54*l.*; all grades of pig-iron, and Siemens' and Bessemer steel bars, nominal.

COAL OUTPUT IN SOUTH WALES.—Some difficulty has arisen in connection with the establishment of Pit Committees in South Wales. The main object of these committees is to take every possible step to improve the coal output. Representatives of the South Wales mine owners have consulted the Coal Controller and he has suggested to the owners' association and the South Wales Miners' Federation that a conference should be held between the two parties to consider the preliminary steps to be taken to establish the Pit Committees in South Wales.

HONOURS TO NAVAL ENGINEERS.—The following honours have, with the approval of His Majesty the King, been conferred upon naval engineers, among others, in recognition of the distinguished services mentioned in the Despatch received by the Admiralty from Vice-Admiral Sir Roger J. B. Keyes, K.C.B., C.M.G., C.V.O., D.S.O., Commanding the Dover Patrol, this despatch relating to the second blocking operation against Ostend on the night of May 9–10, 1918. To be Companion of the D.S.O.: Engineer-Commander William Archibald Bury, R.N. This gallant officer was reported as having greatly distinguished himself in the Vindictive on April 23, and, as soon as he knew another operation was contemplated, volunteered, begging to be allowed to remain in charge of the engine-room department of that vessel. He worked most energetically to fit her out for further service, and on the night of May 9–10 he again rendered invaluable service, setting a fine example to his men. He remained in the engine-room until the last possible moment, and when everyone was clear he blew the bottom out of the ship by firing the main and auxiliary after charges. He was very severely wounded. To receive the Distinguished Service Medal: Engine-Room Artificer F. J. Pickerell. He was one of a large number of other ranks stated to have "volunteered for a very hazardous service, and distinguished themselves in the Vindictive on the night of May 9–10," Lieutenant Crutchley reporting that he found it impossible to select any other names, as all behaved equally well. To receive a Bar to the Distinguished Service Medal: Engine-room Artificers Norman Carroll and Herbert Cavanagh, of whom the despatch states that they, in company with others "distinguished themselves in the Vindictive during the attack on Zeebrugge Mole on April 23. They immediately volunteered for further service in the Vindictive and behaved with conspicuous bravery in that ship on the night of May 9–10." Also in connection with services rendered in the operations against Zeebrugge and Ostend, the President of the French Republic has conferred the *Croix de Guerre* upon Chief Engine-room Artificer F. M. Gale and Engine-room Artificer A. G. Roxburgh, while he has, further, conferred the decoration of *Chevalier* of the Legion of Honour upon Engineer-Lieutenant Albert E. Marden, R.N. Vice-Admiral Keye's despatch also mentions Engineer Lieutenant-Commander Robert Rampling, R.N., as having, in a destroyer, displayed courage and coolness under fire on the nights of April 11–12, 22–23, and May 9–10, and as having carried out his duties with great steadiness, and materially contributed to the success of the operations; Engine-room Artificer Alan Thomas (prisoner of war) and Acting Engine-room Artificer H. A. Harris, as having distinguished themselves in the Vindictive on April 23 and the night of May 9–10.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—True to tradition, August is proving the quietest month in the year, and this despite the demands on trade arising out of the war. The easy conditions in certain branches grow more pronounced if anything, but there are other sections of industry, where great difficulty is being experienced in meeting the calls made upon them. The depression in the crucible steel trade continues, and everything points to the present state of affairs persisting for some time ahead. Wider shipping facilities, permitting of more overseas trade, would help matters, but this is a measure of relief which is not likely to be conceded in the near future at any rate. The output of rolling mills is still restricted by the scarcity of labour. The big gap caused by the recent moulders' strike has now been practically made good.

South Yorkshire Coal Trade.—The coal strike, though only of brief duration, badly aggravated the position in the trade. The pressure for all classes of fuel is very great, but the entire output is going away to meet contract orders, which are heavily in arrears. Best steams are urgently needed by home consumers, and to satisfy export requirements. There is a marked scarcity of cobbles, nuts and slacks; and the position in the house-coal section is very unsatisfactory. Cokes are in strong demand, maximum prices ruling. Quotations:—Branch handpicked, 27*s.* to 28*s.*; Barnsley best silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

SCIENCE MUSEUM; GEOLOGICAL SURVEY.—The report for 1917, on the Science Museum, the Geological Survey and the Museum of Practical Geology, issued by the Board of Education, is now available, price 1*d.* During the year, the Science Museum continued to be closed to the general public, but was open for students and engineers. The report gives a list of the additions made to the museum. The Geological Survey has been busy on work for military establishments and Government departments. The report closes with a list of the additions and donations to the Museum of Practical Geology.

MILITARY SERVICE ACT, 1918.—The Council of the Institution of Electrical Engineers has been in communication with the Ministry of National Service with reference to the utilisation, with due regard to their skill, of members of the Institution called up for military service under the above Act. With a view to their being posted, as far as vacancies are available, to technical units, members of the new military age, on being called up for military service, are therefore invited to communicate with the secretary of the Institution, who will supply them with the form and certificate approved by the Ministry for this purpose.

NEW SHIPBUILDING YARD IN VALENCIA.—We read in the *Revista Minera*, Madrid, that the building of the yards of the Compañia Transmediterranea, at Valencia, is being proceeded with actively. The site covers 6 hectares (14·8 acres), a third of which is to be made land on the sea coast. The shops and works are to cover an area of 12,450 sq. m. (134,500 sq. ft.). There are to be four shipbuilding berths, to take ships from 3,000 tons up to 10,500 tons; the berths will be served by four 3-ton shipbuilding cranes and an 80-ton crane is to be built for putting on board all heavy pieces of machinery. Internal combustion engines are to be constructed in the shops of the new yard for propelling the vessels.

GERMAN SHIPPING AFTER THE WAR.—According to the *Vossiche Zeitung*, the plans of the Imperial Department of Economics for the transition economy of shipping which have been so vigorously opposed by Hamburg in the last few weeks, have but one object, the scrapping and re-casting of orders previously made having for their object the prevention of a dispersal of German shipping and the securing of German bottoms for German trade. A Tonnage Distribu ion Company is to be set up in Hamburg, which is to control all German merchant ships of more than 500 gross tonnage during the transition period. The orders of this company, especially those dealing with exports and the kind of goods to be carried, have to be observed by the shipping companies; freight contracts may only be made with the approval of the company and reports and returns must be made to it. The company itself will be under the supervision of the Imperial Chancellor, who will nominate a Standing Commission for this purpose. It is this Commission which is the chief cause of the Hamburg opposition to the whole scheme. Should there be a scarcity of tonnage, some such plan will be necessary, and it may even be a question of going further and fixing freight rates. Shipping circles deny that there will be a scarcity of tonnage. Up to the end of 1917, about half the German mercantile marine was lost. To take the most unfavourable possibility, namely, the loss of all the ships lying in neutral harbours, it is claimed that Germany would have about a third of its former fleet, that is, 1·8 million gross registered tonnage, as compared with 5 million, and 2½ million tons freight capacity, as compared with 7 million before the war. But before the war Germany carried goods for other countries, so that the remaining tonnage, together with the new ships in course of building, should meet future requirements.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The tone of the Cleveland pig-iron market is strong and cheerful. In the early part of August home deliveries of Cleveland foundry iron under the monthly allocations fell heavily into arrears, due to lack of labour to load the iron, and irregular working of blast furnaces with a consequent reduction of output of the better qualities of iron. Recently, however, by furnaces working more evenly, the quality of make has been better, and means of distribution have shown some improvement, so that cancellation of contracts under the allotment system are very much less than was at one time feared. Quite a brisk business under the September allocations is confidently anticipated. A substantial export trade with France and Italy is understood to be passing through official channels. A good deal of home business in Cleveland forge pig-iron is reported on both early and forward account, trade in this quality not being restricted by the allocation system. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; whilst for shipment to the Allies, No. 3 and the lower qualities are 119*s.* and No. 1 is 124*s.*

Hematite Iron.—By the system of very careful distribution, under strict official supervision, all essential home requirements continue to be met, and a fair amount of iron is available for export to the Allies. Under outstanding licences a few further shipments to Italy have been made through merchants. All new business with both France and Italy have to pass through official channels. Prices are firm but unaltered. Mixed Nos. are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Foreign Ore.—Imports of foreign ore are stated to be coming steadily forward in quite a satisfactory manner.

Manufactured Iron and Steel.—Work has been resumed this week at the manufactured iron and steel works, after the annual local holiday. Full advantage was taken of last week's stoppage to effect repairs to plant. Steel makers have also been able to accumulate supplies of fuel, and are consequently more favourably placed in this respect than for some time past. Output promises to be even larger than recent enormous production. Prices, all round, are very strong. The following are among the principal market quotations to home customers:—Common iron bars, 14*l.* 15*s.*; best bars, 15*l.* 15*s.*; double best bars, 16*l.* 15*s.*; triple best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; iron ship rivets, 21*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*; whilst export quotations, though not fixed may be given as approximately at 2*l.* to 3*l.* above home prices.

Coke.—Supplies to the blast furnaces are, fortunately, slightly better, and every effort is being put forth to meet the absolute needs of the furnaces. Medium blast-furnace coke is 33*s.* at the ovens, and low phosphorus quality 35*s.* 6*d.* at the ovens. Demand for foundry coke for neutrals is as keen as ever, and 65*s.* f.o.b. Middlesbrough Docks is offered freely.

INDUSTRIAL ADMINISTRATION.—It is proposed, during the winter session 1918–19, to institute a series of afternoon or evening lectures on the above subject at the Manchester Municipal College of Technology. Application is invited from persons prepared to deliver one or more lectures at a fee not exceeding 20*l.* per lecture. Applicants should communicate with the registrar before September 14.

MOTOR HAULAGE BETWEEN LIVERPOOL AND MANCHESTER.—Rather more than a year ago an important scheme of motor haulage was established by the Chambers of Commerce of Manchester and Liverpool, a main object being the reduction of useless mileage by securing return loads. Twelve months experience has completely justified the experiment. The manager of the department states that the bulk of the traffic with which it is concerned is that between the two great cities and manufacturing centres in East Lancashire. The system of working began in July, 1917, and from that month to the end of the year the tonnage dealt with amounted to 2,225; from January to August of this year the tonnage had increased to 11,632. With this approximately fivefold increase of traffic the system has now, the manager says, become self-supporting.

RAILWAY TRANSPORT IN FRANCE.—The United States Secretary for War announces that with the completion of the organisation of five new regiment and 19 battalions of railway engineers there will be over 45,000 Americans engaged in railroad construction and operation in France. Nine regiments of railway engineers have been in France since last August. There have been produced for the railroad operation of the War Department in France more than 22,000 standard-gauge and 60 other freight cars and more than 1,600 standard-gauge and other locomotives. In addition to this, purchases of both cars and locomotives have been made abroad. A double line of railroad communication has been secured from the French by army engineers, extending from the coast of France to the battle front, including the construction of hundreds of miles of trackage for yards and the necessary sidings, switches, &c.

THE 300-H.P. MAYBACH AERO-ENGINE.

(*For Description, see Page 226.*)

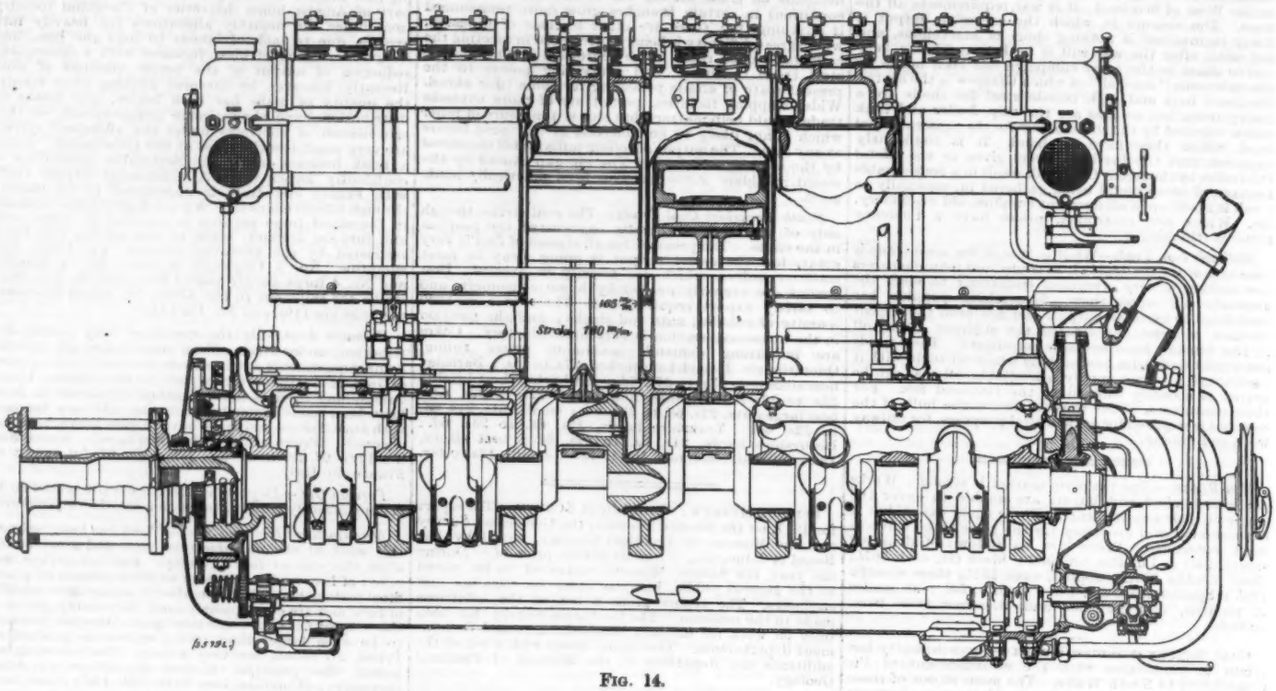


Fig. 14.

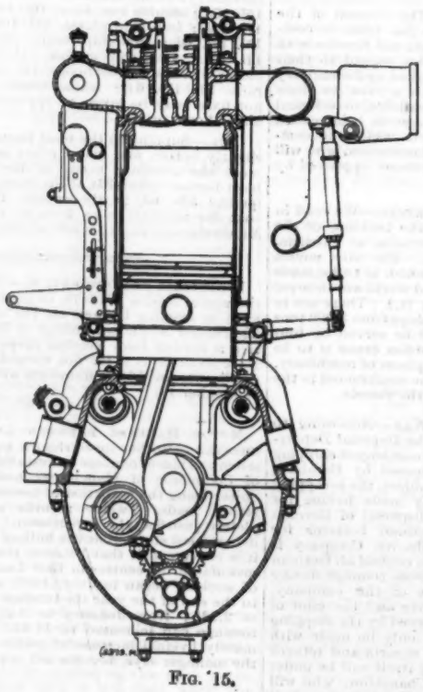


Fig. 15.

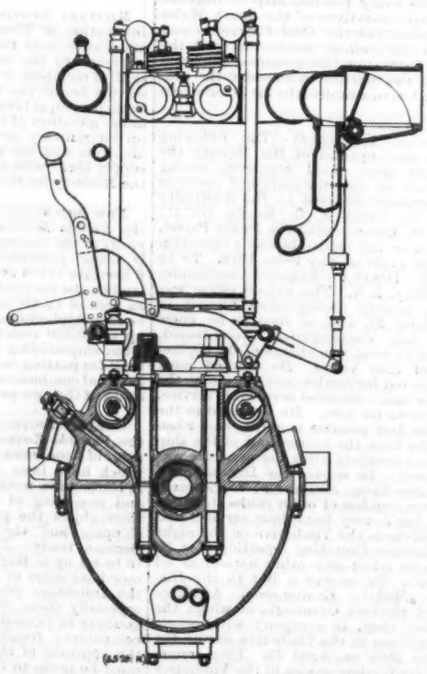


Fig. 16.

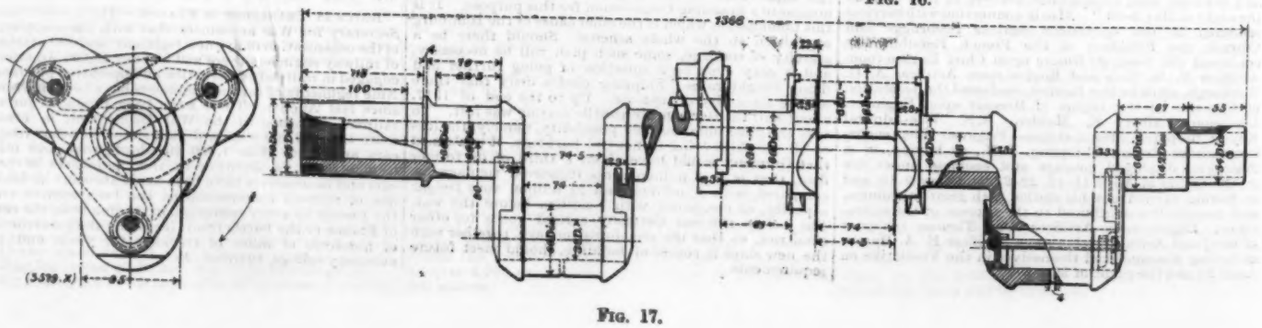


Fig. 17.

THE 300-HORSE-POWER

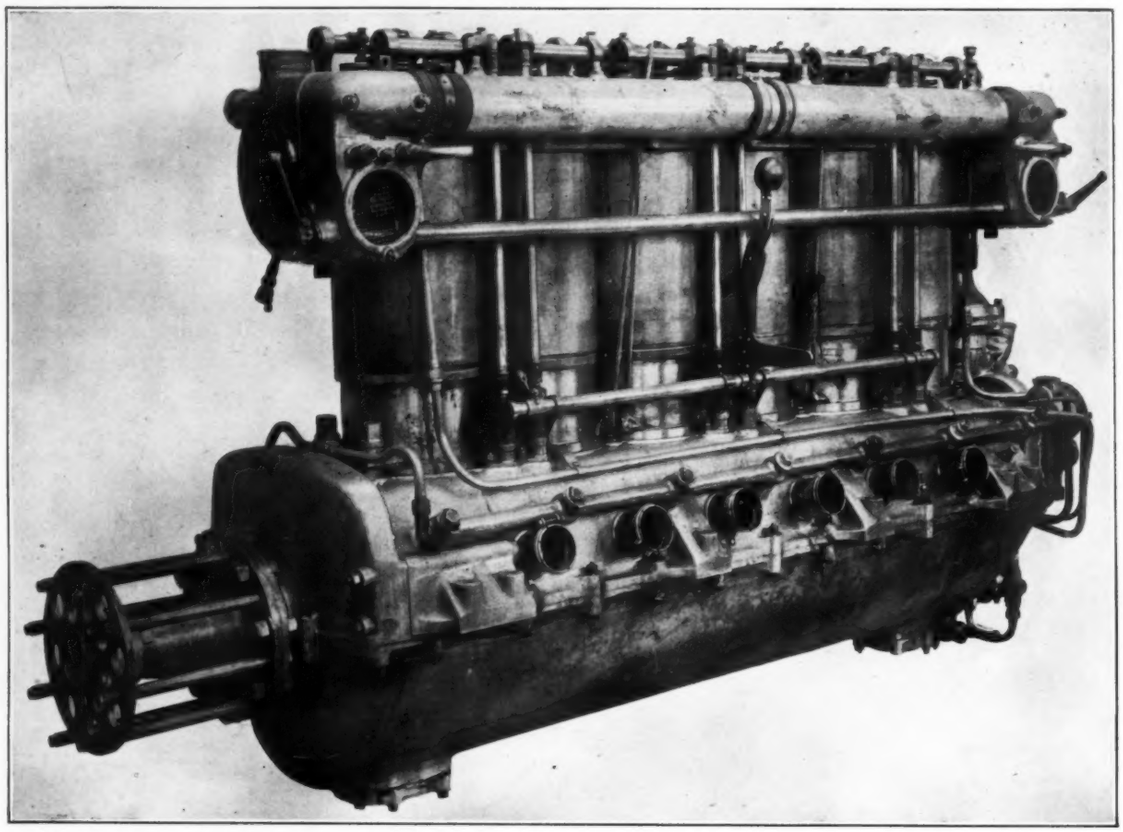


Fig. 1. Induction Side of Engine. (*The Propeller Hub Flange Bolts are not those normally used.*)

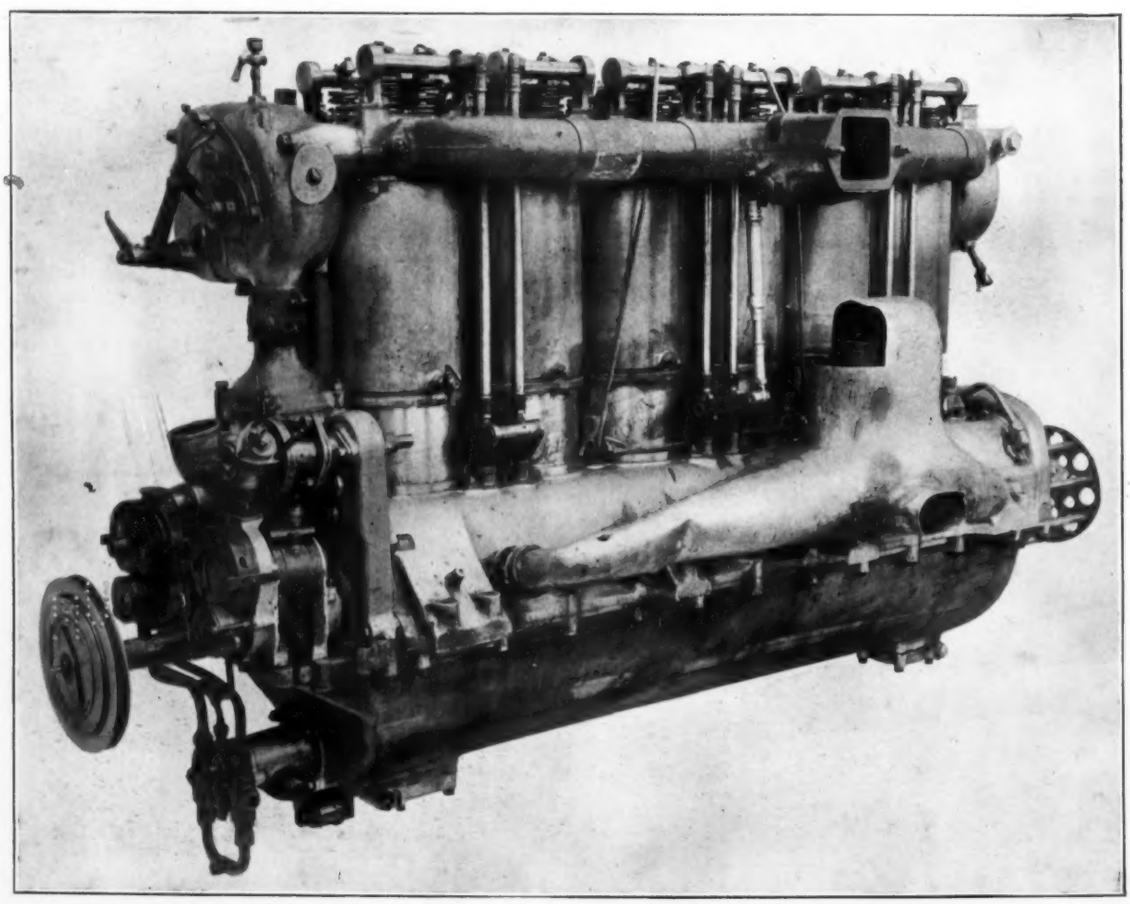


Fig. 2. Exhaust Side View of Engine.

R YBACH AERO ENGINE.

Desc... Page 226.)

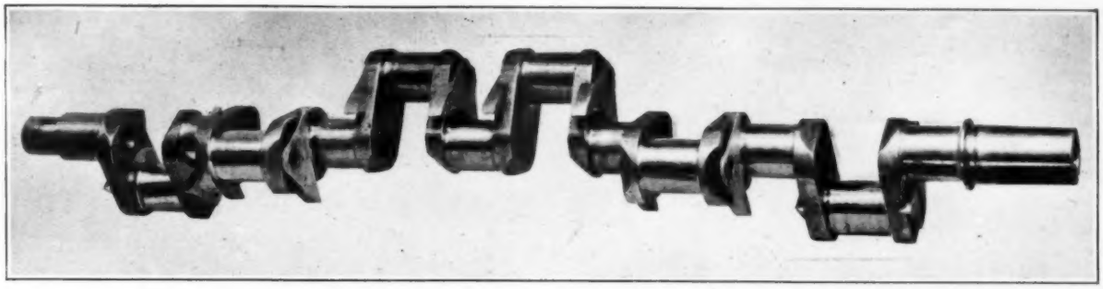


FIG. 5. CRANKSHAFT.

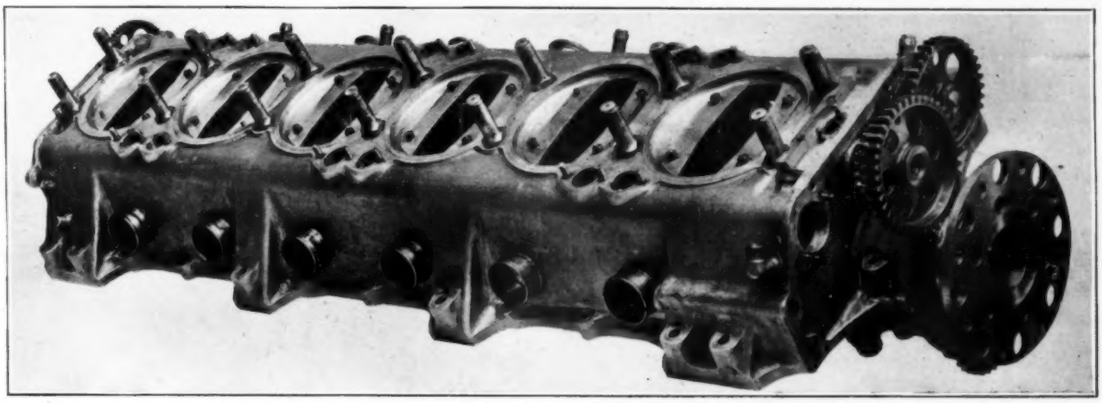


FIG. 6. TOP HALF OF CRANKCASE.

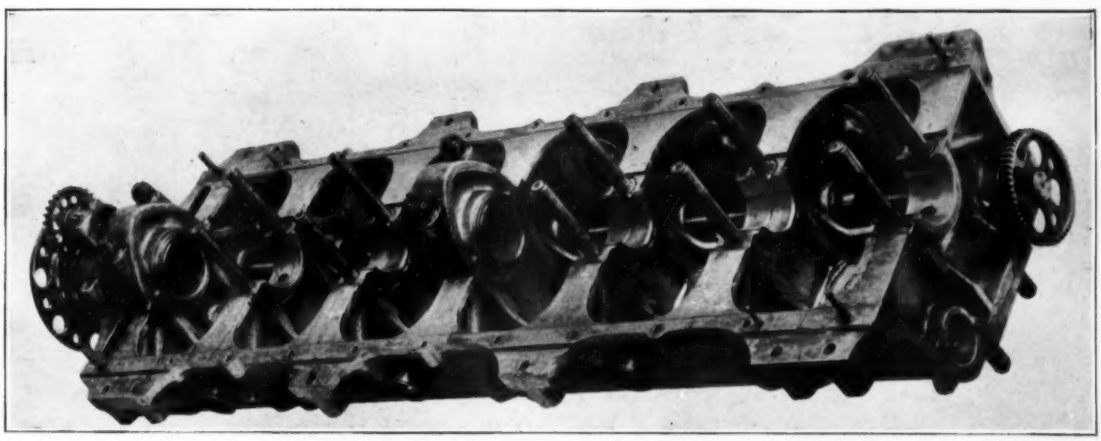


FIG. 7. INSIDE VIEW OF CRANKCASE, TOP HALF.

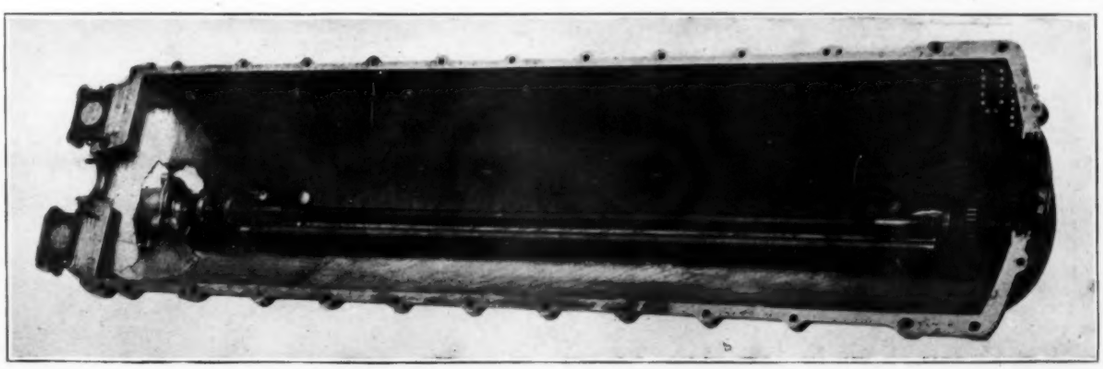


FIG. 8. BASE CHAMBER, SHOWING OIL PUMPS.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3068 and 8596 GERRARD.

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With a Two-Page Plate of the 300-*H.P. MAYBACH AERO-ENGINE.*

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents after June 24th will not have copies for chance customers, therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, AUGUST 30, 1918.

EQUAL PAYMENT FOR EQUAL WORK BY FEMALE WORKERS.

THE subject of the remuneration of female workers in comparison with male workers, and the claim for equal payment for equal work, is again a matter of pressing moment, and one upon which an official pronouncement in the near future is to be expected. The subject may in these columns be regarded in its relation to the women workers in industry proper, and probably the simplest aspect is to be found where such a system of payment by results as piecework is in vogue, that is, when payment is made strictly according to work done, entirely uninfluenced by the time rate of wages. A fixed sum of money is paid for the accomplishment of a certain specified amount of work, *i.e.*, the work carries the price irrespective of the type of labour.

It is claimed in such case that the piece price should remain the same. Where the same class of work is being done both by men and women, this claim is, so far as is known, unanimously conceded; although it is quite possible that, with the same work and piece prices, the cost of the work may vary to some extent on account of several factors. In the first place, the relatively unsettled state of women labour, involving a greater "labour turnover," is the cause of expense and is inseparable from the employment of women labour, due to a certain percentage of female workers remaining in the industry only for a short period and leaving for the prior claims of the home. It had been thought that the timekeeping or regularity of attendance of women workers would be inferior to that of men workers. This has not been proved to be the case. There may be exceptions where the work has been unsuitable, but no case in point has come to be common knowledge. In fact, the timekeeping of women workers has generally been better than that of the men, although it must be stated that women workers have not often been asked to work the same large amount of overtime as men workers. Secondly, Government regulations require that the payment of women workers during the specified training period shall be on a fixed scale and may be much higher, depending on the worker and the class of work, than is justified by the work turned out during training. The period is a fixed one irrespective of the class of work in question, and so may be quite inadequate to the needs of the particular case, which represents a loss. Thirdly, the proficiency, even when fully achieved, as for instance, on highly skilled and varied work, may except in abnormal cases be considerably inferior to that of skilled and trained tradesmen, and thus the amount of material scrapped for which no charge against the worker is made, may be much higher. Fourthly, the amount of power required—electric, hydraulic, pneumatic, &c., per unit of production, as the case may be, will probably be higher according to the less skill of the operator. Fifthly, the time taken may be longer and, in consequence, certain standing charges may be higher. For instance, a shop which, with skilled labour, has facilities for and can turn out 100 units of work per day may be reduced to, say, 80 units owing to diluted labour, many of the overhead charges remaining constant. This increases these charges in the ratio of 100 to 80. Finally, the less expert the operator the greater the amount of supervision; this generally has been allowed for in Government legislation. All these arguments can be advanced, each having in certain cases an undoubted influence on cost; yet, as already stated, the principle of equal piece work rates is generally conceded, meaning in effect the same wages payment per piece, although in some cases and to some extent at greater cost per piece.

To turn to the next application, that of the bonus system, where the time rate enters into the calculation, a time is fixed for the operation or work to be performed and payment made on the time rate plus a percentage bonus calculated on the difference between the time set and the time taken. The time rate is customarily guaranteed, so that if no bonus is earned (the job is then said to be "in debt") the cost of the work is increased in proportion to the time taken. In fact, if the time rate is equal for women and men workers, the work costs more with women workers in proportion as they turn out less work per unit time than the men. This has reference merely to actual wages cost, without reference to the many other factors enumerated in connection with payment on the piecework system. If bonus times or standards are fixed, and agreed upon between the management and the workers, a system could be inaugurated whereby the time rate of women workers would vary between certain limits according to the percentage bonus earned. Assuming that the time allowed for a job were fixed at 100 hours, and 25 per cent. were the bonus generally earned, or expected with 100 per cent. efficiency, if the diluted or women labour were capable of earning the standard or greater bonus, *i.e.*, doing the work in the standard or in less time, such work, as is customary, being passed by the inspector before bonus is paid, then equal work in every way would be performed and equal payment fully justified, excepting where a charge for extra supervision might be made. Allowance for "Labour turnover," training, material scrapped, and extra power, as already mentioned in connection with piecework, would be of very little, if of any, moment when the job was done in standard time and had passed inspection.

Many obvious objections can at once be foreseen to the successful application of a scheme where the time rate increases with the amount of bonus earned as outlined—working on a sliding scale, although it is only in this way, where actual measurement is continuously made and allowed for, that equal payment for equal work can be said fairly to operate with the bonus system as with piece work. It will be clear that with this scheme the time rate between certain limits depends on the bonus earned giving, as regards total wages, a cumulative effect. It is sufficiently difficult at the present time to reach agreements between the parties in the arrangement of time allowances, but with such a scheme as outlined the difficulties would undoubtedly be increased, and on this account the chances of success would be relatively slight, excepting, as already indicated, where fixed times are in vogue, as is often the case with work of a repetition character, and where in setting new times the methods in the past have been such as to establish full confidence.

The case of piece or bonus workers has first been taken because it presents fewer elements of an uncertain nature, due to the necessity with such systems of actually measuring the output. Actual facts replace impressions and opinions. When dealing with pure time workers, where output is not directly measured, the interpretation of Government awards has been that, if a woman is doing a class of work or a single operation in connection therewith which, in the past, has even occasionally been undertaken by a skilled man, she shall receive the same rate as that skilled man, less a 10 per cent. supervision allowance—when the necessity for such can be proved—and less certain Government awards since applied exclusively to male workers. The operation of this interpretation in practice has been simply to prevent women, especially on contracts

to be carried out by the firm at a fixed price, from undertaking many operations which are customarily done by boys and apprentices, although occasionally in the past these have been carried out by fully skilled tradesmen. Women may be entirely suitable for such work, which they could most successfully undertake, although at a lesser rate of output than the skilled worker, and therefore at a prohibitive cost owing to payment of the full time rate. This is not stated in contradiction to the principle of equal payment for equal work, but simply to show that what has been done in the past on time work has been to give equal payment for the same class of work irrespective of quantity. This is a clear incentive to piece work as opposed to the system of time rate of wages or even of bonus systems.

Where time work is concerned it is not easy to suggest a remedy that will succeed, not only in encouraging managers and employees to use the maximum of available diluted labour for the class of work in view, but in meeting fairly the demand of equal payment for equal work. To take, as an example, perhaps the most difficult case, that of a shop turning out a variety of products and requiring—to some extent on that account—a large percentage of skilled workers. A woman worker may be trained in a relatively short period to achieve equal skill with a man on one operation—say, for instance, grinding-in valves, or assembling small repetition parts—perhaps pumps. When so engaged she is entitled to and will claim equal payment with a man who may be working alongside on the same job. But, when the job is finished and the woman worker has to be drafted on to quite a different job—the only one that may be available—the training must be commenced over again, whilst she still retains the full time rate of wages. Allowances are made in the Government awards only for one period of training. If it were possible generally to apply tests and to grade the workers according to tests, as is being accomplished in certain industries, although on repetition work where the reasons for not working piece work or bonus cannot be other than slight, the time rate could be varied between limits according to the proficiency revealed by these standard tests. The same difficulty as mentioned in the case of the bonus system would operate here, that is, to attain agreement as to the nature of, and the value to be put upon, the tests. It would not seem, however, to be an insuperable difficulty to devise a scheme, whereby means of tests and allowances for a number of training periods leading up to these tests, could be arranged to meet a reasonably fair interpretation of the claim of equal payment for equal work.

In the case of workers other than the purely industrial workers where output cannot actually be measured, the spirit of the times upholds the principle of equal payment for equal volume and correspondingly efficient work. Due attention must be paid in assessing equality to all the factors which actually have a direct bearing on the question, and only the chief have been mentioned because to base the claims of equality solely upon sentimental or other reasons will only succeed in severely prejudicing in many directions the cause of the women worker in the future.

COAL CONSERVATION.

Whilst in the light of our present knowledge it is impossible to deny that during past years we have been far from economical in the use of our coal, it is equally true that much of the waste was inevitable, in the very nature of things. Unless our fuel supplies had been so cheap and abundant that a certain extravagance in their use was of little immediate importance, our many great industries could not have been founded and developed. It is indeed during this very process of growth that the knowledge is acquired which makes economies possible, and moreover certain savings are practicable only in large-scale operations, and must of necessity be neglected until a somewhat late stage in the development of an industry. Unfortunately, practices possibly unavoidable during the period of growth tend to be retained as habits. To-day, however, coal is cheaper in America than here, and our industrial future will be heavily handicapped unless we can offset this advantage by greater skill and intelligence in the production and use of this fuel.

That the field thus open to enterprise is both spacious and promising is amply demonstrated in the final report* of the Coal Conservation Committee appointed by the Ministry of Reconstruction. This report, which was issued last week, is a comprehensive document, dealing, not merely with winning and use of coal, but also with its geographical distribution in the United Kingdom. It is shown in the report that there is still the possibility of discovering new coalfields over nearly the whole of the eastern and southern areas of England and in Antrim in Ireland. The superficial beds in these areas are of later date than the coal measures, and the underlying strata are still very imperfectly known. No doubt many of these regions will prove barren. Indeed the data acquired from the deep boreholes sunk at Lowestoft, Culford and Harwich are hardly of a kind to raise sanguine expectations as to the productiveness of the area between Leicester and the East Coast. In other cases, though borings may disclose coal in the still unexplored areas, it may be too deep to be commerciably workable in the present state of mining technology. Nevertheless, making every allowance for disappointments of this kind, there is fair promise of large additions to our known coalfields, and it is estimated accordingly that our probable reserves are equivalent to 580 times our normal annual output. At the same time the newer beds will be increasingly more difficult to work. Indeed, the influence of this factor was already noticeable for some years before the war. Thus between 1897 and 1910 the pit-head price of coal increased by no less than 38 per cent.

One important recommendation made by the committee is that the geological survey should have a right to demand notice of the making of any new borehole or exploratory drive; that the officials of the survey should have full access to such works in progress, and be provided with full records of the results acquired. These might, if desired, be treated as confidential for a period of ten years. As matters stand the Survey only hears of such works by accident, and should the results be such as to lead to no commercial development the whole expensively acquired data may be entirely lost. One difficulty in giving effect to this proposal lies in the inadequacy of the present staff. Attention was called to this matter in 1905 by the Royal Commission on Coal Supplies, and it was proposed that the staff should be increased at a cost of 4,000*l.* per annum, equivalent, say, to the salaries of half a dozen Treasury clerks. The matter, as usual, was referred to the Treasury, and, as usual, Treasury control, so highly esteemed by a certain school of politicians, led to the ignoring of expert opinion and the suggestion was rejected. It is to be hoped that the nation will ere long insist that the higher ranks of our departmental officials shall be recruited from men of a wider culture than has been demanded in the past. In no department is this reform more urgent than it is in the case of the Treasury.

Waste of coal begins at the colliery, and the committee have devoted much attention to the study of these colliery wastes. Whether the figures they have obtained are wholly reliable is possibly open to question, since as Professor Louis pointed out in the discussion on fuel economy at the Newcastle meeting of the British Association, flagrant offenders are apt to disregard inquiries, answers to which might convict them of extravagance, whilst undertakings with a good record have no objection to disclose their figures. The estimate put forward by the committee may therefore be taken as a minimum, and the actual losses may be materially more.

In some important colliery districts the coal is filled into the tubs with forks so that smalls are left below bank. The worst offenders in this matter are the Nottingham and Derbyshire coalfields, the Leicester and South Derbyshire area, and the Warwickshire and South Wales districts. The total quantity thus actually mined, but not raised to bank, is estimated to amount in these fields to 2,325,000 tons per annum. This is less than 1 per cent. of the total output of the United Kingdom, and it is gratifying to note that the figure seems to be diminishing since the growing use of coal-washing machinery has made marketable much that was formerly left below ground. Thus, in Nottingham and Derbyshire, where twenty years ago the coal rejected amounted to 10 per cent. of the output, this loss has now been reduced to 1 per cent. or 2 per cent. The washed coal is used in coke ovens and for making briquettes, and should the plan of generating electric power in the immediate neighbourhood of collieries be realised, even the inferior qualities of small coals may prove of value. Poor coal of course will not stand heavy transport charges, and should be used as near its source as is practicable.

There has been much loss in working the abnormally thick seams which are met with in South Staffordshire and Warwick. The committee quote figures according to which, if present methods of working are adhered to, over 40 per cent. of the coal in these thick seams will be left underground. It is suggested that experiments should be made to determine whether the difficulties which now make this waste inevitable cannot be overcome.

Coal is also left below ground for other reasons. According to the Royal Commission of 1903–5, it will be necessary to leave below ground as barriers or for the support of surface structures not less than 9,500,000,000 tons of coal. Of this huge total more than half is required for the purpose of providing surface support, the remainder being needed for barriers. These barriers have as their chief object the protection of a colliery area from flooding by water from another colliery. Narrow barriers are also sometimes left between adjacent collieries in order to avoid the chance of trespass. The amount of coal thus involved is, however, said to be small. As regards the other type of barrier, the committee suggest that the question should be dealt with by district committees consisting of practical miners, together with mineral lessees and owners.

Water-logging is another cause of loss, some mineral areas in South Staffordshire and near Bristol having been permanently abandoned owing to the prohibitive cost of keeping the workings clear of water. In the case of South Staffordshire it is estimated that 40,000,000 tons of coal and ironstone will be permanently lost failing a solution of the drainage problem. This has been tackled since 1873 by the South Staffordshire Mines Drainage Commission, who have expended large sums in reducing the inflow of surface water to the mines and have also engaged in extensive pumping operations. Their income, derived from a tonnage royalty, is, however, insufficient to enable them to do more than maintain the present status, and their financial position is said to be precarious. The problem should, it is recommended, be further investigated, and the necessary steps taken to ameliorate matters.

Collieries consume a good deal of coal for producing power, the figure varying from 3·80 per cent. to 9·10 per cent. of the output. The average for the whole country is 6·8 per cent. On the other hand, the collieries could in some cases furnish supplies of waste heat to power stations, but it is only in the North-East Coast district that the necessary facilities exist for putting this plan into operation.

One important recommendation made is the immediate establishment of a Ministry of Mines and Minerals. At present it appears that no less than seven separate departments of the Government are concerned in one way or another with coal-mining problems. The Home Office deals with questions of safety in working, the Board of Trade with statistical matters, whilst the Board of Education is responsible for the geological survey. The proposed Ministry of Mines and Minerals would take over nearly all the functions now exercised by other departments and be assisted in its work by Advisory Boards on which would be included representatives of the mining industry (inclusive of workmen), scientific and technical experts, and

* Coal Conservation Committee. Final Report. [Cd. 9084]. H.M. Stationery Office. Price 1*s.* net.

representatives of the principal consumers. The Ministry would, it is suggested, co-operate with the Board of Education in raising the standard of mining technology; the process being assisted by the establishment of State scholarships and bursaries opening the career of mine management to the talents, where these might be found. Technical researches connected with mining should, it is proposed, be dealt with by the Department of Scientific and Industrial Research, with which the Ministry of Mines would co-operate. Reservations to this recommendation are made by Messrs. Nimmo, Forster Brown and Rhodes, who fear that the unity of purpose and administration in matters affecting the industry, which might be expected to follow the institution of a Ministry of Mines, might be too dearly purchased. They express the, probably well founded, conviction that political pressure would be brought to bear on the Ministry to extend its control over the commercial and industrial sides of mining. As Lord Pirrie recently observed, "a Government-managed concern is a badly-managed concern," and any such extension of the powers of the Ministry as the demurrants fear might well have disastrous consequences.

Mr. Robert Smillie, on the other hand, appends a note in which he complains that the proposals do not go far enough. This note constitutes an interesting and instructive illustration of the great gulf which separates the political and scientific type of mind. The former starts from certain plausible premises and deduces its conclusions by logical process, but never attempts to compare these results with actual experience. In the present case Mr. Smillie bases his claim largely on grounds of safety. In short, as the older economists invented an economic man, destitute of any impulse save his immediate personal advantage, so our modern social reformers have invented a theoretical "capitalist" who is swayed by no other consideration than his immediate monetary interests. In each case the object has been to provide a corpus to which theories may be applied without too extravagant an overstrain. As a matter of fact, experience shows that public bodies will accept risks, no "capitalist" dare face. The typhoid epidemic at King's Lynn some few years ago, for example, led to an inquiry which showed that the local authority which owned the water works had disregarded for years official warnings as to the dangerous character of their supplies. No private company dare have shown such recklessness. Other considerations apart, the directors would have to fear a prosecution for criminal neglect. Again, whilst, thanks to her careful study of the methods of railway operation evolved here and in America, Germany had a pretty efficient State railway system, the death-rate from accident, on the German lines, was notably higher than in this country, though the traffic was not nearly so heavy. Further, it is noteworthy that every important safety device or method of working, now in practice originated on privately-operated railways. State systems have, in short, not originated a single material improvement in safety methods and appliances. There is thus little question but that the death and accident rate would be higher in State-operated collieries than under the present system. It is, in fact, much easier to bring the pressure of public opinion to bear on "dividend-hunting directors" than on slack or incompetent public officials. The field for sonorous oratory is far more ample in the former than in the latter case. Moreover, it is impossible to accept without reservation Mr. Smillie's contention that safety should be the first concern of the management of any industry. Such a contention sounds plausible on the platform, but cannot be maintained as universally applicable when examined in the light of experience. Past generations in the United States, for example, had to choose between having no railways or having dangerous railways, and no sensible man denies that they were right in accepting for the time cheaply-constructed and cheaply-operated railways in spite of their concomitant dangers. Individuals inevitably suffered, but these ills were heavily outweighed by the benefit to the community at large.

Politicians no doubt will long continue in their dealings with social and economic questions to rely on their intuitions as to what sounds plausible rather than on a study of the actual facts. Four centuries ago the Schoolmen dealt in identical fashion with problems in natural philosophy. It took a Francis Bacon to effect a break with the bad tradition. The Bacon that will persuade the politician to an equivalent change in his mental attitude is still to find.

British metallurgists have lagged behind their American and German rivals in the economic use of fuel. The by-product coke-oven did not originate in Germany, but was developed there much more rapidly than here, where managers long maintained that such ovens would only produce inferior coke. Professor Bone was, however, able to submit evidence to the Coal Conservation Committee which showed that for blast-furnace purposes at any rate, there was no appreciable difference between "beehive" and "by-product" cokes. The yield of the by-product oven is 70 per cent. of coke as against 56 per cent. for the "beehive" type, and the "by-products" at pre-war prices were worth about 3*s.* 6*d.* per ton. In addition, the by-product oven can be made to furnish 2,000 cub. ft. to 5,000 cub. ft. of high quality gas, which in certain districts in Westphalia is used as a substitute for town gas. Our practice in this regard is improving, and about three-quarters of the coal carbonised for metallurgical coke is now obtained from by-product ovens. Sheffield cast steel makers still insist, however, that for their purposes the "beehive" product is greatly to be preferred. Whether there is a real basis for this claim, or whether the preference is merely a matter of prejudice requires further investigation.

Mr. Benjamin Talbot, in a memorandum prepared for the committee, looks forward to very great saving in the quantity of fuel hitherto used for the production of steel. To get the best results he says that the works should have a capacity of at least 300,000 tons of finished steel per year, and the plant should include by-product coke ovens, blast furnaces, steel furnaces, and rolling mills, all under one management. In this way surplus heat and power available at the coke ovens and blast furnaces could be utilised in other stages of the manufacture, so that the total quantity of raw coal to produce from the ore 1 ton of finished steel would be brought down to 35 cwt.

About one-third of the total coal output of the country is used for the production of power. Most of this is used very uneconomically. An ingenious analysis of the available figures leads to the conclusion that the average coal rate per horse-power hour is not less than 8·03 lb. Investigations carried out in the North-East Coast district, in works where steam was replaced by electricity from the power company's mains, showed the average figure there to be over 7 lb. per horse-power hour. In certain areas where textiles are produced in quantity and power-generating units are comparatively large, local figures are certainly much lower. But save in such cases as those covered by the Tyneside Power Company's investigations reliable figures are hard to get. Test results seldom provide a fair index to the normal consumption of reciprocating engines in average practice. When, for example, turbines were first introduced into the French Navy, comparative trials made with reciprocating engines showed the latter to be more economical at all but maximum powers, yet in actual service it is said that this relative superiority was not maintained, since valves and glands were not kept up to the condition of steam-tightness to which they had been adjusted in preparation for the comparative tests.

Whatever the actual average figure may be, there is little doubt that the coal consumed is much higher than the conditions warrant. The question as to how this state of affairs should be reformed was considered in an interim report published by the Coal Conservation Committee last year, and this is now re-published in the Final Report. The proposals made were discussed in our issue of January 4th last, page 14, so they need only be referred to briefly here. The committee premise that the future prosperity of the country is bound up in a large addition of our industrial output, and that this will only be possible if power is used to a very much greater extent than in the past. It is important that this increase of power should be obtained without any increase in our present total consumption of fuel. Moreover, great electro-chemical and electro-metallurgical industries can flourish here only if power be provided at rates comparable with its cost in the hydro-electric stations of Norway and the United States. This, the committee report, is possible, if present systems of power production and distribution are revolutionised. One great difficulty to be overcome lies in the fact that Parliament gave a wrong direction to the development of electric power distribution in this country, and large vested interests have accordingly grown up which will have to be placated.

The committee propose that for electric power purposes the country shall be divided up into 16 areas, each of which will be fed from super-stations situated in positions where ample cooling water is at hand, fuel cheap, and space is available for the location of electro-chemical and electro-metallurgical factories and for coal carbonisation works, should it prove practicable to operate the station in conjunction with by-product recovery plants. These super-stations being so large could afford to employ an adequate technical staff, who would ensure the utmost economy of fuel. High-tension mains would convey the power to distributing centres, and to these mains waste heat stations would contribute their quantum of energy, wherever such waste heat was available. It is noted that the waste heat stations connected up to the East-Coast system supply over 30,000,000 units annually. The construction of these trunk mains would necessitate some changes in the law governing way leaves.

The scheme thus outlined is an attractive one, but may be difficult to finance. It is one thing to develop a great power scheme step by step as was done on the North-East Coast and at Chicago, and quite another to effect a revolution out of hand by the construction of enormous and costly works. Such works might well prove a source of loss rather than of profit during the earlier years of their development. Undertakings started on a grandiose scale seldom prosper at the outset, and the scheme, if adopted, must accordingly be developed gradually from somewhat modest beginnings. In the meantime, however, Parliament should certainly take steps to prevent the extension of existing extravagant systems of power supply. The stations now in use at Manchester, Liverpool, Sheffield and Birmingham have all inadequate water supplies, and have accordingly to operate with cooling towers. This implies an increase of at least 5 per cent. in the fuel bill as compared with more favourably-situated stations, and working costs are, moreover, otherwise increased. Birmingham, it is noted in the report, is contemplating the construction of a new station of 300,000 kw. rated capacity. This is to be situated within the city boundaries so as to retain the rates. The site selected will make the use of cooling towers imperative, so that the station can never attain a really high standard of economy in the use of fuel.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

(*Continued from page* 212.)

Glass. Refractory Materials. Asbestos.—In dealing last week with these materials we stated that the National Physical Laboratory had not contributed to that section of the exhibition; we find, however, that we had overlooked the refractory exhibits of the Laboratory. These consist first of samples of zirconium oxide, crude (brownish in colour), washed with sulphuric acid, and pure; a basic sulphate, a new compound; two oxychlorides, one of which is a new compound; and some zirconium metal, discoloured by carbide. The pure oxide and the compounds are white crystalline or amorphous, the electrically-fused oxide looks a little yellowish. There are, further, crucibles, muffles and tubes of silicon carbide (carborundum), and among these two large crucibles used for melting glass at very high temperatures; one of these crucibles is externally coated with a thin layer of silicon carbide, the other not; the former

had stood the temperature without suffering any distortion, the other had collapsed. The small fireclay crucibles of the Laboratory, of large-thimble size, are provided with a side pocket for inserting the thermocouple. Very interesting are the specimens (prismatic bars) of gauge glasses which had been tested by prolonged exposure to the action of high-temperature steam. The one specimen, of a special glass made in the Laboratory, had almost kept its size and shape; the other, of a commercial glass much used for this purpose, had shrunk to about a third of its size; a third specimen, of ordinary glass, would have been added if it had not completely disappeared during the test, having been dissolved by the superheated steam. We should also notice the electric thermostat of Messrs. Haughton and Hanson, developed at the Laboratory, to which we have referred in our reports on the work of that institution, and the specimens of aluminium alloys.

We may also supplement our notice of the important exhibition of optical glass by Messrs. Chance Brothers by stating that the firm now manufacture more than 70 types of optical glass, and that their fluor crown glass exhibited surpasses in smallness of dispersive power any pre-war Jena glass. The firm guarantees standards of homogeneity.

The Turner Brothers Asbestos Company, of Rochdale, makes a very fine display of asbestos, white, blue, red and black, as fibre, yarn, mattings, packings, sheetings, beltings and insulators; also of asbestos cement slates and sheetings, and firefelt and magnesia blocks; some of the sheets and packings consist of several corrugated layers, leaving ample air channels. The Cape Asbestos Company confines itself to the blue asbestos from the Cape.

Diamond-Tools. — Though Messrs. L. M. Van Moppes and Sons display some fine diamonds among their very instructive exhibits, they are not in any sense jewellers, and their stones from the Cape, South West Africa and Brazil are all mounted in tools for grinding and cutting, or otherwise utilised for scientific purposes. This industry, mainly fostered in America and Germany previously, has also been considerably developed in this country in connection with the war requirements, and diamonds and diamond tools are now extensively wanted in the automobile and shell industries for use in making crankshafts, camshafts, ball bearings, grinding cylinders internally, and tool grinding, and not merely for rock drilling and glass cutting.

The stones used are known as bort, shapeless lumps often, though real diamonds, but inferior as gems; the carbonado (carbon) or black diamonds from Bahia (Brazil) are also diamonds, though they look more like small lumps of coal. To the tool maker, the origin of a diamond is of little importance; but every stone has to be selected for its particular purpose, and to be mounted and appropriately treated, when it will efficiently execute the work it is required to perform. In giving diamonds new edges and facets, use is made of diamond powder, produced by pounding the stones in a steel mortar; with the aid of this dust and of revolving steel discs, into the edge of which diamonds may be forced, pebbles for telescope lenses, &c., are slit. For ordinary glass-cutting, edged crystals are needed, and the stones are sorted according to the number of cutting points they possess; even the smallest stones, of which 80 go to the carat, leaving each stone a weight of 0.04 grain, may show six such points under the lens. In rock drills, which have been used since 1863, usually in diameters of from 1½ in. to 2½ in., but also up to 1½ ft., bort and carbon stones will do, from 1½ carats up to 20 carats. Such stones, set in circular saws, also serve for stone cutting. German firms have practised diamond rock-drilling to a much greater extent than British firms. Emery and carborundum wheels, and other abrasives, are trued up with diamond machine or hand tools.

Some of the hand tools exhibited are rods of steel, 8 in. or more long, in the plane end of which the stone is mounted. The other end of the rod is corrugated so that the man can grip it tightly. After a certain amount of wear, the stone, originally of ¼ carat or ½ carat, can be reset, the end of the rod being cut off, if necessary. We have seen tools in the workshops of the firm which had been reset five times in the course of two months, the date and the loss of weight, say, 0·1 carat, being stamped on the tool each time.

The mounting is an engineering art, requiring also technical diamond experience; the stone should be set up against the grain of the diamond, and the determination of the grain is a matter demanding special knowledge. But the life of a tool depends much also on the treatment of the tool in service. According to the old practice the stone was brazed into a cavity in the steel. In some cases the stone is placed in a cavity, approximately of the shape of the stone, formed in a piece of copper, let into the steel, and the stone is secured in position by caulking the copper round it. Molten steel may also be cast round the diamond; the steel flows into the irregularities of the stone and, contracting, grips it tightly. The cavity may also be made in the steel, and the surrounding metal be then fused by the acetylene blow-pipe or electrically. These devices for mounting in steel alone are special methods of Messrs. Van Moppes. For use in out-of-the-way districts, where skilled resetters are not available the stone is held in place by a coned cap screwed down upon it, different-size cones being used for stones of different sizes; the socket for

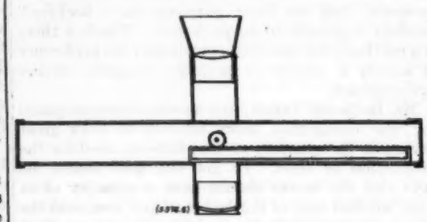


Fig. 1.

the stone may also be made slotted and be squeezed up, or the stone be secured with the aid of a screwed-on wedge.

The turning of materials like ebonite for magneto-insulations, and of hard rolls for paper-making, requires specially-shaped and faceted diamonds, bort or carbons mounted into facing, cutting and edging tools. A very accurate and smooth finish can be obtained with the aid of diamond cutters. Examples of all these varieties of setting are on view. The diamond draw-plates for wire drawing, at present much in demand for aeroplane and cable work, are mounted within cylindrical blocks of steel or bronze. In the exhibits the internal diameters of these dies range down to 0·05 mm.; the tungsten filaments for lamps require dies of 0·0015 mm. The slightly yellow, but clear and sound diamonds from South-West Africa, are much appreciated for making these dies. In perforating the stones, a start is made with a sharp diamond point; a slender steel spindle is then moved up and down vertically until the stone is pierced after many hours of patient work. In the cups for bearings for the moving system of electricity meters, diamonds now replace rubies. Conspicuous among the exhibits of Messrs. Van Moppes are a fine octahedron in its blue ground from Jagersfontein; a cubical diamond of 87·3 carats from the Wesselton Mine, South Africa; four large tools for 36-in. abrasive wheels, with four stones totalling 46·35 carats; and many diamonds of the flat triangular shape, which is very convenient for wire-drawing purposes.

Optical Instruments.—The war has led to the optical instrument maker being as busy as any manufacturer, and progress does not merely consist in an enormous increase in the number of instruments and apparatus supplied, such as binoculars, searchlights, periscopes, gun-sights, range and height finders, and photographic apparatus. There had to be, also, a fundamental change in the methods of manufacture to meet the demand for known and novel types of apparatus. Each new method of offensive or defensive warfare has brought its own special instruments, as Mr. S. D. Chalmers points out in his article contributed to the catalogue. The medical services have also required new types of microscopes and apparatus for bacteriological research, and among these special cells and fine rulings might be mentioned.

Lens-grinding machinery was before the war made either by the individual user or was imported from abroad; fine machines are now exhibited by Messrs. Bryant Symons and Co. (four-spindle machine, for blocks up to 6 in. diameter); they also show a high-precision screw-cutting lathe with all accessories. This latter was recently fully described and illustrated in our columns.* Messrs. A. J. Greenway show a six-spindle machine, and Messrs. G. N. Tanner a six-spindle turret-head auto-polishing machine for eyepiece work and other glass-grinding machines. Some of the exhibits we are going to notice under the present heading are classed with physical and measuring instruments in the exhibition.

The exhibits of the Admiralty—compasses, binnacles, azimuth mirrors, sextants—include compasses for aircraft and tanks and special exhibits from several firms: Messrs. Kelvin, Bottomley and Baird; Messrs. Heath (liquid compasses); Messrs. Hughes (marking compasses); Messrs. Dobbie McInnes (R.D.C. special steering compass). The Army Spectacle Depot, established in January, 1916, for the supply to H.M. forces of spectacles and ophthalmic equipment at home and over seas, shows mainly glasses and instruments designed or manufactured at the depot. The "mules" globes shown are hollow glass spheres blown from tubes and sealed hermetically, and placed in the eye cavity to form a stump for the cap or shell of an artificial iris, so that the eye can move freely and appear less sunken in its orbit. Specimens of eyes made in the department by the German "tube" method for artificial eyes are also on view; they consist of a glass tube, a few millimetres in diameter, at the end of which a complete eyeball is blown. Mr. Albert E. Waters, of Birmingham, who exhibits his artificial eyes on a stand of his own in the surgical section, describes them as much superior to the German eyes, which were apt to crack and burst.

The two compact sighting telescopes shown by Messrs. Aldis Brothers, of Birmingham, are designed for use on aircraft in connection with the signalling lamps of the firm. The instruments exhibited by Messrs. Bellingham and Stanley consist of refractometers, a saccharimeter, a simple polarimeter and a measuring micrometer, which is a microscope with a sliding stage admitting of measurements within 0·001 mm. The three refractometers are of the butter type (for examining oils and fats), a dipping refractometer (for diluted solutions) and an improved Abbe, made by the firm since 1914, for which superiority over the original is claimed.

The self-recording theodolite of Messrs. C. F. Casella is designed for following the movements of pilot balloons sent up for the purpose of studying air currents; the movements of the theodolite in azimuth and altitude are automatically recorded on a chart. The theodolite is of the right-angle type, the rays from the objective being reflected by a prism so that the observer always looks in a horizontal direction. There are two divided circles, each of 18·5 cm. diameter; each periphery is provided with a groove in which rests a fine chain which conveys the movement of the telescope both in altitude and azimuth to two pen carriages travelling over guide rods in front of the drum. Accessory parts of the instrument are: The clock, which rotates the drum once an hour and which is coupled with an attachment to lift the pens from the chart so as to obtain a time-mark once every minute; a micrometer eyepiece to determine the distance of the balloon by measuring the angle subtended by a tail of known length hanging down from the balloon; and a cloud attachment, consisting of an etched glass disc, 63 mm. in diameter, a mirror and a sun-glass, these parts being required for watching clouds and also as a finder for picking up the balloon and placing its image in the centre of the field.

Among the exhibits of Mr. J. H. Dallmeyer we notice the lenses for photography from aircraft, the kinematograph projection lenses, and the gauge-projection lenses. Messrs. Adam Hilger's interest-

* See page 578 of our last volume.

ing exhibits will be dealt with next week. The varied exhibits of Messrs. Joseph Lucas, of Birmingham, consist of daylight signalling lamp outfits, and electric equipments, starting and lighting devices for tanks and aircraft, for heating clothes on aircraft, &c.

The photometer for testing the illuminating power of flashes and star shells, shown by the Illuminating Engineering Society, is a new form of the photometer which a committee of the society devised in 1917. The instrument is a box of wood, 11 in. square, 4 in. deep, which the observer holds lengthways in front of his eyes. He looks through an aperture in front normally closed by two hinged flaps which screen the eye from external light during observations. The box is painted dead-black inside, but there is a "scale" of 14 letters, A, B, C, . . . N, stencilled out of cardboard at the back of the box; this scale is illuminated by a small glow lamp, so placed that the light is brightest at A, and weakest at N. The observer looks through the slot forming one of the letters at a test surface, illuminated by a portable source of light which is placed at the spot where the illumination is to be measured; the observations may be taken directly under a flare, and only one observer is needed, whilst the original instrument required two observers.

The wedge pyrometer of the Optical Pyrometer Company, the invention of Messrs. Cochrane, of the Ormsby Iron Works, Middlesbrough, is a handy small instrument, for the workshop and furnace house, not claiming accuracy within more than ±10 deg. C. It can be used for temperatures starting from 500 deg. or 600 deg., when visible glow commences, up to 2,000 deg., and the range of an individual instrument is about 400 deg. The diagram, Fig. 1, on the opposite page illustrates it, but is not exact. The instrument has the shape of a cross, rectangular in section, made of sheet brass. The short arm of the cross is a telescope, provided with an eyeguard; the observer looks through this telescope at the object and turns a milled head until the object becomes faint and finally disappears; he then reads off the temperature on the scale which is marked in divisions of 20 deg. By turning the milled head he slides a rectangular casing inside the long arm of the cross up and down by means of a rack; the casing encloses a long prismatic block of glass which is divided by a diagonal plane into two halves, cemented together, each a long triangular prismatic wedge, one of optical glass, the other of a special red glass. The rack movement brings different parts of the square prismatic block and thus different thicknesses respectively of colourless and of red glass into the field of the telescope; the greater the thickness of the red wedge in the line of sight, the more faint the image of the furnace tap hole or glowing steel looked at will appear. The scale is marked on the inner casing, and there is a small opening for taking readings in the outer casing, in the part common to the two arms of the cross. The instrument is obviously of the approximate kind, but it is very simple, and may be very useful in the steel, glass, coke works, &c., in which it has been adopted.

Messrs. C. A. Parsons and Co., of the Heaton Works, Newcastle-on-Tyne, show an imposing parabolic reflector for a searchlight, 150 cm. in diameter, 65·4 cm. focus, and a smaller signalling mirror, 10 in. in diameter, 6 in. focus, both fitted with Parsons' lead and copper wire backing; the wires form a wide mesh netting. The other exhibit of pure anhydrous dextrine may have something to do with the silvering of mirrors; inspection gauges used in connection with the manufacture of shells are also exhibited. Messrs. Rheinberg and Co., of Holborn and Willesden, make a speciality of graticules, a term which was as unfamiliar to many people before the war, as their production on a large scale was over here. Graticules, crosslines, circles, scales, eyepiece micrometers, &c., are essential parts of any optical instrument of precision and indispensable to the gun-sights and other apparatus for determining distance, size and direction. Yet the manufacture of graticules had hardly been developed outside Germany. The graticules of Messrs. Rheinberg are produced by grainless photography, or by filmless photography, both special processes of the firm. In the former case of grainless photography (on a thin celluloid film) the graticule is generally fitted with a cover glass, which is cemented on. The lines are from 0.02 to 0.0002 in. in thickness, and are black opaque, or grey semi-transparent, amber, composite (black and amber), or clear on black ground, or white opaque. With the latest development, the filmless photography, no cover glass is required, as the image is formed in untarnishable metal in the glass itself, and irremovable by solvents or by scraping. Here the lines may be opaque black, grey semi-transparent, or black by transmitted light, and white by reflected light or when the graticule is illuminated through the edge of the disc. Non-parallax scales of 100 mm. divided into ½ mm., *e.g.*, by filmless photography, and platinised or semi-platinised surface mirrors of superior reflecting power, which will stand rough handling, are likewise on view. Messrs. W. F. Stanley and Co. exhibit a large variety of instruments—theodolites, inclinometers, sextants, miners' dials, levels, aneroids, pentagraphs, &c. Some of the instruments, like slide-rules, protractors, the bomb-dropping sight (which is set for the height and the speed of the aeroplane with the aid of cams), and a tautness-meter (for aircraft wires), do not contain any lenses or glass. The optical exhibit of Messrs. Taylor, Taylor and Hobson, of Leicester, is an aviar lens for aerial photography. The other exhibits are screw-measuring machines of the suspended needle or prism type and gauges for screw threads.

Electric Apparatus, Motor Starters.—The most noteworthy recent development has been in magnetos, in insulating materials, and in radiotelegraphic and telephonic appliances. The last-mentioned class of apparatus, however, is not directly represented in the exhibition. We will now notice the stand of the Igranic Electric Company, Limited. The chief

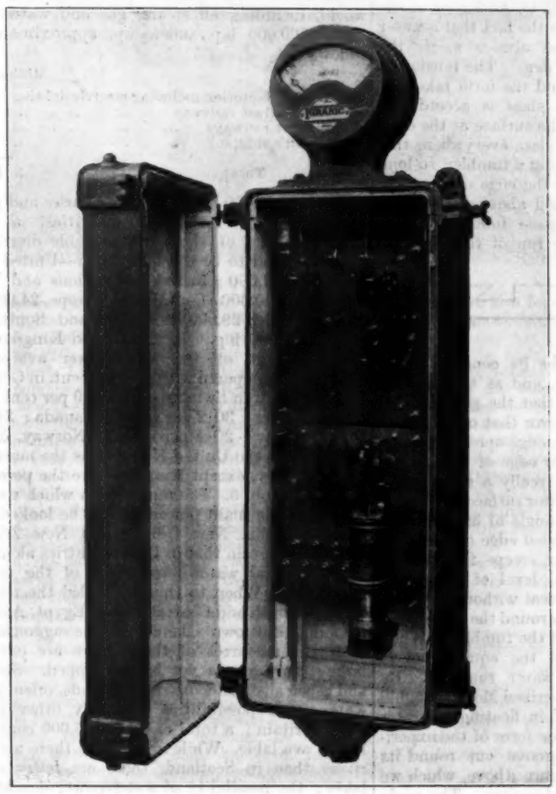


FIG. 2.

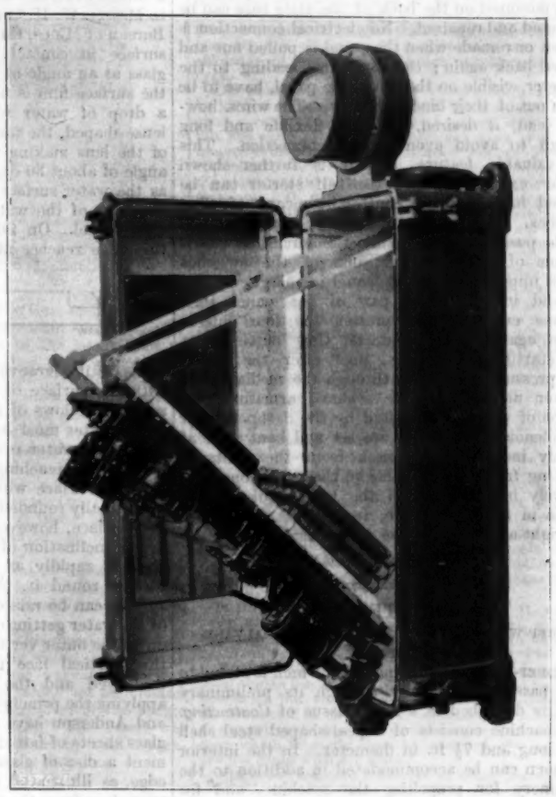


FIG. 3.

FIGS. 2 AND 3. IRONCLAD MOTOR-STARTING PANEL; THE IGRANIC ELECTRIC COMPANY, LIMITED, LONDON.

exhibits of this firm are their self-acting electric motor starter, and a fine collection of remarkable coils wound by their Leesons patent universal winding machines, which we shall illustrate next week. The Igranic patent ironclad motor-starting panel, illustrated in Figs. 2 and 3 on the preceding page, is of the multiple-finger pattern designed to close from 2 to 10 contacts in succession without the intervention of any commutating devices. Two single-pole main switches are mounted together and are interlocked within a very strong iron casing having a junction box at the base and a current meter at the top. The whole panel can be examined through the window of the casing; for closer inspection the whole front can be swung open on hinges, and after loosening two winged nuts on the top of the casing, the whole panel can also be pulled forward, so that the resistances and other parts mounted on the back of the slate base can be inspected and repaired. No electrical connection is broken or remade when the panel is pulled out and pushed back again; the two wires leading to the ammeter, visible on the top of the panel, have to be taken out of their binding screws. The wires, however, can, if desired, be made flexible and long enough to avoid even this disconnection. This is a valuable feature, and it is further shown at the exhibition how the self starter can be utilised for automatic control by means of float switches, thermostats, pressure regulator and simple push buttons. When the circuit is closed by one of these devices, one of the switches in the upper part of the panel is energised; the solenoid in the lower part of the panel then receives current, and presses the four fingers shown against their contacts, thus cutting out the starting resistances, one after the other. The pressure is exerted through the mediation of a lever attached to the solenoid armature, the motion of which is regulated by the dashpot under the solenoid; the fingers are set and bent to be at slightly increasing distances from the contacts, counting from left to right, so that they come successively into play, until the lever hook, hardly visible in the photograph, touches its contact on the right and cuts out the last resistance.

(To be continued.)

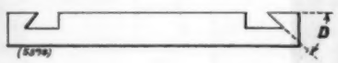
NOTES.

Deep-water Diving Machine for Salvage Purposes.

A deep-water diving machine, which is stated to have passed successfully through its preliminary tests, is described in a recent issue of *Contracting*. The machine consists of a pear-shaped steel shell 9 ft. long and 7½ ft. in diameter. In the interior two men can be accommodated in addition to the machinery for propelling the machine, and for drilling or doing other work below water. It is proposed to use the machine for salvage operations in deep water, the hull being designed to withstand the pressure due to 1,000 ft. head. Air sufficient for 24 hours is carried inside the shell, stored in bottles under a pressure of 1,700 lb. per sq. in. On the outside of the hull of the machine are mounted four 3,000 c.p. electric lamps in globes fitted with strong guards. Windows and bulls-eyes allow the crew to investigate their surroundings as lighted up by these lamps. The power supply required for propelling the machine and for other purposes is obtained from a source above surface through a flexible cable. By an ingenious arrangement of electric magnets the machine can attach itself to the side of a sunken vessel but can also creep over the surface of the latter. These magnets, which have each a holding power of 2½ tons, are mounted on pairs of horizontal or vertical screws. By cutting out one set of magnets the remainder can be used as an abutment and the machine warped backwards or forwards or up and down by turning the screws, and when the latter are at the limit of their travel the magnets previously cut out are energised again, and when they have attached themselves in turn to the hull they serve as an abutment for another movement, those previously in use being cut out of action, and their screws run back. The amount of motion in any direction is registered inside the hull, so that holes can be drilled accurately in desired positions, and then, by warping the machine, as already explained, another tool can be brought to register accurately with a hole thus drilled. This tool inserts a special type of expansion bolt which when put in place automatically locks itself there. The machine can, moreover, it is stated, put a steel plate over a hole, can drill and tap holes through both plate and hull and screw in set bolts making an excellent joint. The preliminary trials of the machine were carried out in New York Harbour in 105 ft. of water.

"Flotation."

The development of the flotation process of separating ores has led to some interesting studies on capillarity by the United States Bureau of Mines. It is a matter of common knowledge that a tumbler can be over-filled with water. According to Messrs. W. H. Coghill and C. O. Anderson, of the Bureau of Mines, this is due to the fact that a water surface in contact with glass always meets the glass at an angle of about 30 deg. The tension in the surface film is uniform, and the form taken by a drop of water resting on glass is accordingly lense-shaped, the tangent to the surface at the edge of the lens making with the glass everywhere this angle of about 30 deg. In filling a tumbler, so long as the water surface is below the edge of the glass the edge of the water is raised above the general water level. On filling the glass fuller, however, this edge reaches at last the top of the tumbler.



It has still, however, to make its constant angle with the surface of the glass, and as this is horizontal it follows of necessity that the general level of the water must be higher than that of the glass. As further water is added the edge spreads further out, and on reaching the outer edge of the glass it meets a surface which is not really a sharp edge, but is really rounded. The water surface still meets this surface, however, at the angle of 30 deg., and as the inclination of this rounded edge of the glass changes rapidly as the water creeps further and further round it, the general level of the water surface can be raised a good deal without the edge of the water getting completely round the corner and on to the outer vertical face of the tumbler. When this vertical face is reached the equilibrium is destroyed and the surplus water runs off. By applying the principle here described Messrs. Coghill and Anderson have succeeded in floating on water glass sheets of fair size. In one form of the experiment a disc of glass has a groove cut round its edge, as illustrated in the figure above, which we reproduce from the *Scientific American*. The angle D is equal to the contact angle between water and glass. When the disc is placed on a water surface the water does not spread beyond the edge of the groove, and the water level may stand as much as 0·54 cm. above the surface of the plate. This hydrostatic head is more than sufficient to buoy up a plate of the thickness of thin window glass. In fact, a certain load of sand can be added without swamping the raft. In some other experiments a plate 8 in. long by 3½ in. wide was successfully floated. With large plates, however, it is difficult to get a water surface sufficiently still to ensure success. In such cases as above described, the floating is due practically wholly to the hydrostatic head, as the direct upward pull due to the surface tension is small compared with the weight of the plate. In the flotation of ores, however, the fragments are so small that the direct effect of the capillary tension is relatively much more important.

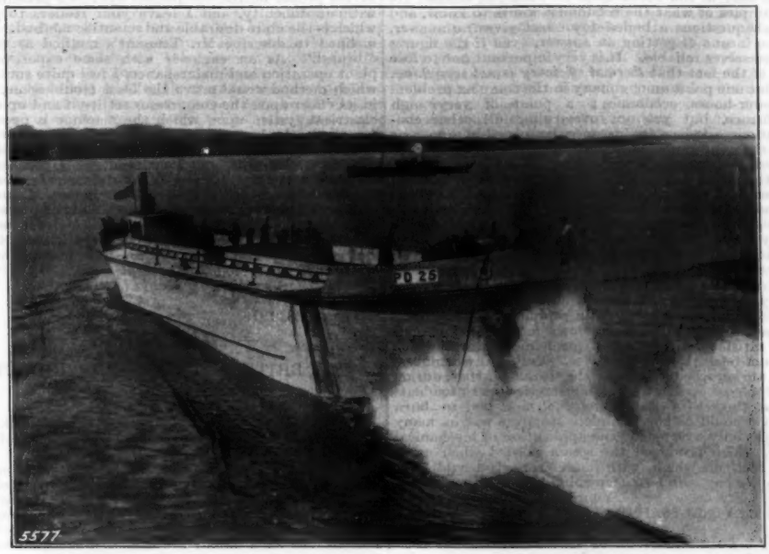
Water-Power in the British Empire.

The Water-Power Committee of the Conjoint Board of Scientific Societies, appointed to report on what is at present being done to ascertain the amount and distribution of water-power in the British Empire, state in their report recently issued that in order to enable the Empire to recover, with any degree of rapidity, from the financial burden imposed by the war, it will be necessary to develop in a much greater degree than heretofore its latent resources. The wealth embodied in its mineral resources, wheat areas, forests, and the hundred products of its tropical dependencies is almost incalculably great. But it must be realised that without an ample supply of cheap energy much of this wealth must always remain latent. The available sources of energy are, for practical purposes, few in number; they comprise our fossil fuels, our oil fields and oil shale deposits, and our water powers. The supplies of solid and liquid fuels are strictly limited, and their ultimate depletion is assured; long before they are actually exhausted, increasing scarcity is bound to put up their cost to a level much higher than that now obtaining. In view of this, the utilisation to the utmost possible degree of the water-powers of the Empire becomes of paramount importance. The present power demand of the world, including all steam, gas and water-power, is 120,000,000 h.p., made up, approximately, as follows:—

	Million h.p.
World's factories, including electric lighting and street railways	75
World's railways	21
World's shipping	24
Total	120

Of the 75,000,000 h.p. used for factories and general industrial and municipal activities, a rough approximation of the most probable distribution would appear to be the following:—United Kingdom, 13,000,000; British Dominions and Dependencies, 6,000,600; Continental Europe, 24,000,000; United States, 29,000,000; Asia and South America, 3,000,000 h.p. In the United Kingdom only 8·3 per cent. of the water-power available is utilised, as compared with 43·4 per cent. in Germany, 25·5 per cent. in Switzerland; 24·9 per cent. in the United States; 30·2 per cent. in Canada; 24·4 per cent. in Italy; 20·4 per cent. in Norway, &c. In this respect, the United Kingdom is the most backward country, except Russia, where the percentage utilised is only 5. The report from which we quote says that the main powers are to be looked for in Canada, India, New Guinea and New Zealand; it is fairly certain that in these countries alone there is a potential water-horse-power of the order of 40,000,000. When to this are added the resources of East, South and Central Africa, Egypt, Australia, &c., and our own islands, in the aggregate the hydraulic resources of the Empire are extremely large; they are as yet barely tapped. Scotland, and especially the Scottish Highlands, offers greater water-power possibilities than any other part of Great Britain; a total of some 235,000 continuous h.p. is available. While in England there are larger rivers than in Scotland, there are fewer natural lakes; the possibility of water-power development is also restricted by the general lack of elevation. Ireland's possibilities of power also appear to lie in her rivers. In the mountainous area of North Wales, where the rainfall is high, two power installations have already been established, developing some 12,000 e.h.p.; there are possibilities of further development in this region. The main conclusions of the report are to the following effect:—1. That the potential water-power of the Empire amounts in the aggregate to from 50,000,000 h.p. to 70,000,000 h.p.; 2. That much of this is capable of immediate economic development; 3. That, except in Canada and New Zealand, and to a less extent in New South Wales and Tasmania, no systematic attempt has as yet been made by any Government Department to ascertain the true possibilities of the hydraulic resources of its territories, or to collect the relevant data; 4. That the development of the Empire's natural resources is inseparably connected with that of its water-powers; 5. That the development of such enormous possibilities should not be left to chance, but should be carried out under the guidance of some competent authority. The report ends with a number of recommendations, in which is advocated the formation of an "Imperial Water Power Board," or "Imperial Conservation Commission," including a representative from each of the Dominions and Dependencies, to deal with the water-power available in the Empire in all its various aspects.

1,000-TON REINFORCED CONCRETE BARGE.



Although a reinforced concrete barge of 400 tons capacity has been in use on the cross-Channel service for some months, the vessel launched on Saturday last, the 24th inst., at Lake Shipyard, near Poole, is the first 1,000-ton reinforced concrete sea-going barge completed in the United Kingdom, and forms one of the fleet of similar vessels at present in course of construction at Admiralty extension shipyards in different parts of England, Scotland and Ireland.

Lake Shipyard was established by Messrs. Hill, Richards and Co., Limited, of Albemarle-street, W., in association with the Marine and General Concrete Construction Syndicate, Limited, London, in December last year, on the lands attached to Lake House, formerly the residence of Colonel Guest, the total area of the site being nearly 250 acres in extent and having an excellent water frontage of 1¼ miles on Poole Harbour. The slipways, buildings, plant and equipment were laid out to suit concrete shipbuilding by Mr. Anthony G. Lyster, of Sir John Wolfe Barry and Partners, who acted in the capacity of consulting engineer.

The yard is in communication with the London and South-Western Railway system, and is conveniently situated for the delivery of timber and other materials by water. Leaving out of account the barge just launched, there are now eight barges of 1,000 tons deadweight capacity on the slips, and three steam-tugs of about 800 h.p. have been commenced.

With the exception of one isolated slip, where an experimental barge is being constructed for the Admiralty on the system of Captain J. H. Waller, D.S.O., R.E., and under his personal direction, the slipways form a continuous range, and when finally completed will provide accommodation for the simultaneous building of 16 vessels ranging up to 2,500 tons dead-weight carrying capacity.

All the vessels under construction on this range of slips are being built in accordance with the designs of Mr. E. O. Williams, the hull in every case having a double bottom and double sides. The interior arrangement is that laid down in the Admiralty specification and general drawings, the holds being separated by transverse bulkheads, and the spaces fore and aft providing accommodation for the captain, mate and men, as well as for a steam boiler, coal bunkers, store and equipment generally; a steam winch is fitted in the upper deck near the bow.

The principal dimensions of the barge launched are —

	Tons.
Deadweight capacity	1,000
	Ft. in.
Length between perpendiculars	190 0
Beam at load line	33 0
Moulded depth	15 6
Draught when loaded	12 0

The vessel was built very largely by men recruited from the building trades, having no previous experience in shipyards.

As the ancient borough of Poole has been associated with the shipbuilding industry for many centuries, having provided four ships in the time of Edward III, for the siege of Calais, it is by no means surprising that great interest has been taken in the latest class of vessel to be built in the locality and, unlike their remote predecessors, happily dedicated to the joint service of our own forces and those of our gallant allies on the opposite shore of the English Channel.

Among those attending in official capacities were the Mayor and Mayoress of Poole (Major and Mrs. Dolby); Mr. Staples and Mr. H. A. Flinn, representing the Director-General of Merchant Shipbuilding; Colonel Ferretti, Naval Attaché to the Italian Embassy; Mr. Anthony G. Lyster, M.Inst.C.E.; and Mr. Robert Park, Resident Surveyor to the British Corporation.

The launching ways were similar to those ordinarily employed, the gradient being 1 in 20. The ceremony of launching the vessel was performed by the Mayoress of Poole.

It is interesting to know that the experience gained in the building of this pioneers vessel has already resulted in the introduction of various improved methods of procedure, some of which we understand have been adopted in the construction of the barges and steam-tugs now on the stocks. The vessel was constructed to the classification of the British Corporation for the Survey and Registry of Shipping.

Japan Builds Ships for America.—The first of the 45 vessels which Japan agreed to build for the American merchant marine in return for an allocation of steel has now been delivered. The vessel is of 9,066 tons deadweight, and was built by the Kasawaki Dockyard Company, at Kobe.

Compression Strength of Glass and Quartz.—Some new experiments on the crushing strength of glass and quartz, conducted by G. Berndt, of the Optical Works of Goerz, Berlin-Friedenau, were communicated last December to the Deutsche Physikalische Gesellschaft. The experiments were made on an Amsler testing machine, maximum load 30 tons, first with cubes of the glasses and quartz, and then with cylinders. It was observed that, when cubes were used, the strength decreased as the cube edge was increased in steps, from 5 mm. up to 15 mm.; the cylinders afterwards used had a diameter of 5 mm. and the same height. The faces were either all polished, or only those faces were polished to which the pressure was applied; this made little difference, however, and the rate of applying the load had likewise little influence on the results; with stained glass, but with well-annealed glass the strength was by 10 per cent. or more smaller with quick loading than with slow loading. The final crushing to powder took place with almost explosive violence. A borosilicate glass showed an average strength of 15,200 kg. per square centimetre when strained and a higher average of 16,900 kg. (maximum 18,400 kg.), when well annealed. In the case of quartz the crushing strength was greater, 25,000 kg. per square centimetre (maximum 28,000 kg.) when compressed parallel to the optical axis, than when the pressure was at right angles to the axis (25,000 kg. to 27,000 kg.). These values for quartz are higher than those previously found by A. Winkelmann and O. Schott and Rinne, but somewhat lower than those found for glass.

"COAL SAVING BY SCIENTIFIC CONTROL OF STEAM BOILERS."

To the Editor of Engineering.

Sir,—The letter of your correspondent "Morgan," in your issue of the 9th inst., contains some very useful suggestions on standardisation of boilers, boiler settings, fittings, &c.

Whilst not admitting the desirability or necessity for obvious reasons for one standard size of Lancashire boiler, knowing well that any sized boiler of this type can be efficiently stoked either by hand or machine, I do think the settings should be standardised in every newly seated boiler. I have laid down many boilers during the last few years on the following lines, the results fully justifying their adoption:—Depth of bottom flue half the diameter of the boiler, width half the diameter plus 6 in. Side flues, width at the narrowest point one-eight diameter of boiler. Distance from back end of boiler to brickwork one-third diameter of boiler, or where superheaters are used plus 6 in. I consider, however, the most important part of boilers for standardizing are the fire grates, so that they bear a constant ratio to the outlet for the gases at the rear end of the furnace flues as it is the relationship these two factors bear to each other which decides both the duty and efficiency of any tank boiler not excluding the marine type.

The present standard grate for any 30-ft. Lancashire boiler is 6 ft. long independent of its diameter, and this gives a ratio of heating surface to grate area of 25 to 1, but the ratio of grate to outlet for gases is a variable quantity differing with each sized boiler. It is quite common to see several sized boilers in one range, assuming there are three, the respective diameters being 7 ft., 8 ft. and 9 ft. diameter, and if the chimney draught is equal, say to 1,000 ft. per minute, the first-mentioned boiler due to having 4 sq. ft. of grate to 1 sq. ft. of outlet, will have an air velocity through the furnaces of 250 ft. per minute.

The next size has a ratio of grate to outlet of 3½ to 1 air velocity through furnaces, therefore 285 ft. per minute, whereas the 9 ft. diameter boiler has a ratio of 2¾ in. to 1, the air velocity 366 ft. per minute. If the air supply per pound of coal for these boilers was the same as given in Mr. Brownlie's articles in Engineering, July 12 and 19, the approximate evaporations per square foot of grate per hour would be 100 lbs., 140 lbs. and 170 lbs. or per boiler 3,300 lbs., 5,460 lbs. and 7,775 lbs. By giving a proportion of 2 sq. ft. of grate to 1 sq. ft. of outlet in each of the above boilers, and assuming the same chimney draught the air velocity through each boiler furnace would be 500 ft. per minute, the length of grates being reduced respectively to 3 ft., 3 ft. 9 in. and 4 ft. 9 in., thicker fires could then be maintained and the quality of combustion increased at, say, 13 per cent. The evaporation per pound of coal would be so increased that the rough evaporation under general present conditions requiring 1 ton of coals could be done with the 2 to 1 ratio for 17 cwt. This, on a boiler burning 1,000 tons of coal per year, means a saving annually of 150 tons.

A furnace 17 sq. ft. area with 8½ sq. ft. outlet for gases with 18 lbs. of air per pound of coal, will radiate approximately 15 per cent. more heat than 33 sq. ft. of grate under present general conditions.

Mr. Brownlie, in his letter which appeared on page 169 *ante*, thinks a reduction in grate areas would be generally beneficial, but that my suggestions of a grate 4 ft. long for a boiler 8 ft. diameter is too drastic. I would suggest to anyone in doubt to prove the case by practical experience which is easily done by covering the last 2 ft. of the fire grate with fire brick.

I have letters from a number of steam users who have adopted my suggestions relative to reduced grates, and from others who have acted on their own initiative, and in every case savings in coal are being effected ranging from 100 tons to 170 tons per boiler per year, the cost of alteration per boiler being that of a few fire bricks.

I quite agree with both Mr. Brownlie and "Morgan" on the subject of fan draught, and have a case before me where with two 30 ft. by 9 ft. boilers fitted with induced draught the coal saving effected in favour of the fan is 8 per cent. With a constant draught and a constant ratio between grate and outlet a high furnace temperature is maintained, smoke under such conditions is impossible and economy therefore becomes automatic. It is deplorable that we are wasting in our homes, and our industries, &c., approximately 50,000,000 tons of coal per year, the very element on which we depend for the production of armaments, for the carrying, feeding and clothing of our soldiers, for our own and the world's future safety: what is the cause of this wastage? We fail to recognise the simple elementary fact Mr. Brownlie has so clearly demonstrated that we are giving 12 lbs. more air per pound of coal than is required for good practical working conditions. There may be other minor details but the broad fact remains the same, i.e., lack of rightly proportioning the air and coal supplied to our furnaces.

The remedy for minimising coal consumption is briefly outlined in this letter, to which may be added the value of a 4½-in. firebrick wall down the centre of each furnace flue for about 15 ft. and a 9 in. midfeather down the centre of the bottom flue. This brickwork greatly assists the boiler by converting the heat of the gases into radiant heat which along with the increased proportion of heating surface per square foot of grate due to reducing its area will increase the boiler efficiency without economiser or superheater to approximately 70 per cent. instead of 57 per cent. as at present. The true measure of a steam generator is the difference between the initial and terminal temperature, and this, in Mr. Brownlie's report, calculated from his figure, is a little

short of 1,400 deg. F., but with the modified grate, &c., the proposed difference is over 2,200 deg. and under which conditions the 25 sq. ft. of grate in a 8 ft. diameter boiler will radiate 40 per cent. more heat than the 38 sq. ft. mentioned in the report.

In conclusion, an evaporation of 250 lbs. of water per square foot of fire grate should be our minimum, and if this was made compulsory the way of securing it, as already suggested, would be quickly adopted.

I am, yours faithfully,
W. H. Casmey.

Milnthorpe, Wakefield, August 21, 1918.

To the Editor of Engineering.

Sir,—The general inefficiency of boiler plants, demonstrated so vividly in Mr. Brownlie's article is a most serious matter, and the reasons for same deserve the fullest investigation. Even if it were argued that the proportion of plants tested were not representative of those in operation all over the country (I believe the author is justified in claiming that they can be taken as such), the fact is proved that at least every four out of five plants tested are capable of radical improvement, and, further, in the country's interests at the present time, it is the bounden duty of every manufacturer or user of coal to ask himself the question "Is my plant working at the utmost efficiency within economical limits?" and if it cannot be decided either way from lack of the essential information, surely the user should take steps at once to have his boiler plant thoroughly tested so that an accurate heat balance-sheet could be laid before him. It is as vital in many respects as the yearly financial balance-sheet.

One fact appears to me to be really necessary if economical steam production is to be obtained, viz., a school for training firemen and stokers. Surely in amongst a considerable number of the 250 plants tested, it was found that the manufacturer had done his utmost to provide his boiler plant with all the necessary accessories requisite for economy being obtained, but waste in fuel has resulted, due to inefficient or unskilled stoking.

It seems to me the time has arrived when training schools should be established at various centres throughout the country, for the purpose of equipping firemen with the requisite degree of skill in the combustion of fuel, and this training should cover experience with forced draught (fan or steam jet), induced draught, natural draught or any other established system, together with experience in use of the various types of mechanical stokers. The training school should issue an efficiency certificate to the fireman on leaving, and with this in his possession the manufacturer should be willing and eager to pay a really decent wage which, in my opinion, would be amply returned in economy.

It is well known that in the past colliery boiler plants have not been laid down with as much attention to the saving of coal as they ought to have been, this is a matter clearly indicated in Mr. Brownlie's tests and every colliery proprietor should be informed of this fact, with a view to a remedy being applied.

Are our city electric power stations using the ratepayers' money as economically as they ought to be in this respect? These plants are usually equipped in a most efficient manner, but it would be very interesting to see the results tabulated for a number of these boiler plants, in fact I suggest that these public concerns be obliged to publish their results and I have no doubt some of our technical papers would only be too pleased to tabulate the data. A proper authority should have power to make inquiries in regard to the inefficient ones, and within reasonable limits to advise one as to the remedies being carried out in a certain time. At present we are up against coal rationing, with as yet unrealised grumblings and discontent attendent to it. Let us, therefore, examine the matter from a man-power standard and see what it represents.

Assuming Mr. Brownlie's estimate correct, that if all the boiler plants in this country were brought up to an obtainable efficient state, no less than 15,000,000 tons to 20,000,000 tons of coal would be saved per annum. The output from a colliery is approximately 300 tons coal per annum per man employed, so that the waste above actually represents labour in the mines to the extent of 50,000 to 60,000 men. One can realise how the country would have benefitted at the present time had all the boiler plants been operated on the economical and scientific lines suggested by Mr. Brownlie.

Yours faithfully,
"Mancunian."

August 26, 1918.

To the Editor of Engineering.

Sir,—May I be allowed to add to my previous communication a few words in reference to Mr. Brownlie's letter published in your issue of August 16?

Mr. Brownlie says he is "at a loss to understand" my statement that he gave no sound basis for judgment concerning boiler-house economy. If my meaning was obscure, perhaps the following will elucidate it. First owing to the method adopted for deducing one "standard" boiler test from 250 tests, made during the last eight years on boiler plants of widely varying types, sizes and working conditions, I do not consider it possible that the figures of this boiled-down test (to use Mr. Brownlie's phrase) are themselves scientifically reliable. Mr. Brownlie defends the method he adopts, but I do not think he proves its adequacy. Secondly, even if it could be proved that these figures give a true average of present-day boiler-house practice, such an average does not supply what is needed by the coal economist. He asks questions such as: Is the Lancashire the most economical steam generator; if not, which type is so? In what direction and to what extent is economy affected by variations in the rate of combustion per square foot of grate, and of evaporation per square foot of heating surface? Ought the gases to be allowed to leave the boiler at a comparatively high temperature, leaving part of the heat to be recovered by feed-water heaters, or is it better practice to aim at using as much as possible of the heat in the boiler itself? These, of course, are but samples of what the economist wants to know, and to such questions a boiled-down test gives no answer, and no means of getting an answer, even if the figures be themselves reliable. It is very important not to lose sight of the fact that *thermal efficiency is not everything.* It is but one point among many in the complex problem of power-house economics; a point of very high significance, but yet not over-ruling all other considerations. It has, for instance, happened in numerous cases that the replacement of one fuel by another has effected the engineer's object of reducing power costs, even though it has involved some reduction of thermal efficiency. This and other such points must be borne in mind, and, after a careful re-reading of Mr. Brownlie's article, I consider that my comment is quite justified. At any rate, I have explained what I meant.

As to mechanical firing. I have left myself but little space to deal with this. I am very much surprised at Mr. Brownlie's statement that hand-firing gives greater facility in burning low-grade fuels. I can only adopt Mr. Brownlie's own method, in replying to "Morgan," and assure him that I have known many cases of fuels being satisfactorily burnt on mechanical grates, which could not be dealt with otherwise. Very many engineers will, I am sure, bear me out in the statement that, during the 1912 coal strike, when boiler-house superintendents were at their wits' end to get fuel, and had to burn whatever could be got, complete stoppage was in many instances only averted by the application of mechanical grates, which produced the steam needed when using waste fuels on which, with hand firing, it would have been quite impossible to keep going.

Yours faithfully,
Bolton, August 26, 1918. G. A. Rossetti.

To the Editor of Engineering.

Sir,—It is amazing to read the explanations generally given throughout the daily Press for the threatened shortage of coal in this country. The usual accusing finger has been pointed at Labour. The faults of the miners have been dragged into the light of day and elaborated upon until the general public must almost be convinced that the British miner is pro-German and wholly responsible for the present serious coal position.

I make bold to say there is no greater patriot in the world than the average British miner. There are other causes for the coal shortage, the responsibility for which lies in higher quarters than Labour. These causes may not be quite so apparent, but they are infinitely greater in their disastrous effects than any shortcomings of the miners. The indiscriminate recruiting of miners (who volunteered in their splendid thousands) in the early days of the war and the recent "comb-out" in the mines, have brought in their train what easily ought to have been foreseen. A parallel case is that of the highly-skilled engineering and shipbuilding workers with results no less disastrous.

Large numbers of miners are being recalled from the army, but their efforts cannot materially affect the output for some time to come. The shortsighted policy which desperate necessity has just revealed, forces upon us the closer study of economical coal consumption or the substitution of other forms of fuel.

It is clearly the duty of engineers who have coal-consuming plant under their charge, to go very thoroughly into the economics of their fuel consumption and to apply their technical knowledge to reduce to the lowest possible limits the consumption of coal.

There are without doubt thousands of coal-consuming plants of all kinds throughout the country which, either through lack of the necessary technical supervision and consequently unscientific and wasteful methods of combustion, or through plant of poor design, consume a very much larger amount of coal than would be necessary with careful local supervision and plant of efficient design.

It is astonishing how many plants are running without data being kept to check their efficiency which in many cases must be very low, especially stations where inexperienced hand stoking is used.

Those enthusiastic engineering economists who have for many years been endeavouring to impress upon the Government the desirability of utilising our natural water power resources and the equally persistent advocates of large central generating stations, to supplant the many systems of electricity supply will find some satisfaction from the fact that the country's extremity is their legitimate opportunity.

Yours faithfully,
James Bowman, A.M.I.E.E.

13, Park-avenue, Chelmsford, Essex,
August 27, 1918.

TESTING AIR COMPRESSORS.

To the Editor of Engineering.

Sir,—I note Mr. Tennant's remarks in your issue of the 23rd inst., and see I was in error in referring to control by suction throttling, due to my writing without the original article by me at the time. However, this does not affect my contention that English practice lags behind American practice. It requires little imagination to realise the effects of *instantly* throwing off and on the entire load of over 600 brake horse-power at intervals of a few seconds only if the pressure regulation is anything like close, as it should be. The effects would be much worse than from the operation of an electrically-driven winding plant. In American practice for a plant of anything like the size of that in question "step-by-step regulation" would be adopted, *i.e.*, reducing the output from the compressor, and consequently the load, 25 per cent., 50 per cent., 75 per cent., and finally 100 per cent., according to the demand. Control of the air valves proper on the compressor cylinders permits this without difficulty, and I leave your readers to judge which is the more desirable and scientific method. I am inclined to describe Mr. Tennant's method as simply "brutal." As an engineer with some experience in plant operation and maintenance, I feel quite sure as to which method would prove the least troublesome, both in its effect upon the compressor set itself and upon the electrical system upon which the machine is operated. I scarcely think there will be two opinions about it.

Then as to the method of creating a vacuum in the cylinders, this will not, I contend, be as efficient as simply "breathing" as it were, at atmospheric pressure. Cooling effect by the latter will be improved, and by the former there will always be some loss of power due to compression each stroke, which will increase as time goes on, due to leakage back through the delivery valves and even by piston leakage also. Such leakage has no effect upon the system I advocate.

Yours faithfully,
W. W. F.

August 28, 1918.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

To the Editor of Engineering.

Sir,—I should be very glad if you would kindly correct in next week's issue an error which I feel sure is due to misapprehension.

In the paragraph which refers to the exhibit from this department, statement is made in the middle of the second column, page 212, of the issue of August 23, that "The formula and tables of resistant power of various glasses to soda, caustic soda and hydrochloric acid on the same stand are due to Sir H. Jackson." Unless something unexpected has happened to our stand (which should contain nothing else but our exhibits), you will find that the large table of results are clearly headed, "Results on Tests carried out in the Department of Glass Technology, The University, Sheffield." They represent part of an elaborate series of tests which have been going on in the department for a long time.

I shall be glad if you will kindly insert this correction.

Yours faithfully,
W. E. S. Turner.

Department of Glass Technology, The University,
Sheffield, August 26, 1918.

[We regret that a mistake has been made, which is partly due to the contraction of two sentences into one. At the stand referred to there is a Table, now nailed to the wall, bearing the title: "Comparison of the Resistant Power to Chemical Agents carried out by the Department," this Table giving details of tests of British and foreign glasses. Another card draws attention to "Electric Light Bulbs made in the Department from a 28-lb. melt of leadless glass. Formula by Sir Herbert Jackson." The arrangement of the stand has been slightly altered since our first notice was written.—Ed. E.]

Economising Coal.—Complaints as to the dirty character of the fuel now supplied have been frequent, so that it is of interest to note how trouble arising from the same defect has been overcome in the States. According to a communication from Mr. A. D. Bailey, published in the Journal of the American Society of Mechanical Engineers, the difficulty of obtaining good coal has led in some cases to power stations purchasing only sufficient good coal to cover the period of maximum load, as it is possible to get along during "off peak" period with lower grades or fuel which can be more easily obtained. The good coal is kept in a separate store and is distributed to the boilers either by hand or by special equipment during the peak periods.

A New Shipbuilding Yard.—Lord Pirrie, who is on a tour of inspection through the shipbuilding areas of the North-East Coast, visited the Egis yard on Monday, the 26th inst. This yard, on which work was begun in November, is now nearly completed. It covers a site of nearly 16 acres on the banks of a North-East Coast river, and is interesting for the fact that it is entirely driven by electricity. It has four berths, each capable of building a ship of 430 ft. long by 56 ft. beam, and of about 10,000 tons deadweight. The principal buildings are erected on each side of the berths. On the south is a platers' shed, 532 ft. long by 100 ft. broad. Direct gas-firing furnaces for frame and plates are installed. The slips are provided with 20 steel derrick posts, 98 ft. long with 35 ft. derricks, four on each side of each ship, with an independent electric winch capable of lifting 3 tons to each derrick. Six other portable electric winches are also provided for use where required. On the east side of the yard are the general stores, joiners' shop, mould loft, mast shed with machines for making all masts, derricks, ventilators, &c., and a carpenter's shed. On the north-east side is a fitting-out quay, 466 ft. long. Along the quay is a 30-ton electrically-driven travelling crane capable of lifting 30 tons at a radius of 54 ft. and 10 tons at a radius of 90 ft., the height above crane wheels being 94 ft. On the west side are the beam shed, smiths' shops, finishing shops, plumbers' shops, &c., all equipped with the latest and most efficient machinery. Electric power, lighting, pneumatic piping, water pipes, &c., are taken down between each berth, and every facility is provided for utilising pneumatic power to the greatest possible extent.

THE METALLOGRAPHY OF TUNGSTEN.*

By ZAY JEFFRIES,† B.S., Met. E., Cleveland, Ohio.

TUNGSTEN has the highest melting-point of all the known metals, namely, 3,350 deg. C.; it is one of the hardest of the metals; it has the highest equiaxing or recrystallisation temperature after strain hardening of any pure metal known. It is particularly distinguished because, when composed of small equiaxed grains, it is extremely brittle and fragile at room temperature, and when possessing a fibrous structure it may be ductile and pliable at room temperature. The common ductile metals act in exactly the opposite manner in this respect.

The present paper will include a brief note regarding the manufacture of wrought and ductile tungsten. The metallography of wrought and ductile tungsten in the various stages of manufacture will be considered more or less in detail. The general relationships between the properties of tungsten and other metals will also be considered.

A discussion will be given explaining why fibrous tungsten is ductile at room temperature, even though past experience with other metals would indicate that it should be brittle. Finally, a brief note regarding some new fundamental metallographic propositions relating to all metals will be given.

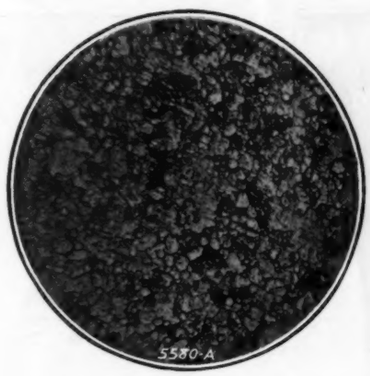


FIG. 1. SINTERED TUNGSTEN INGOT. × 152.

FIG. 2. SWAGED TUNGSTEN ROD, 0.214 IN. DIAM. × 152.

FIG. 3. SWAGED TUNGSTEN ROD, 0.125 IN. DIAM. × 152.

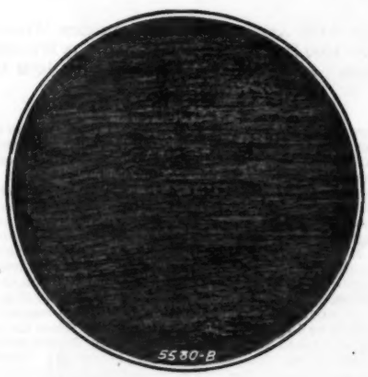


FIG. 4. SWAGED TUNGSTEN ROD, 0.082 IN. DIAM. × 152.

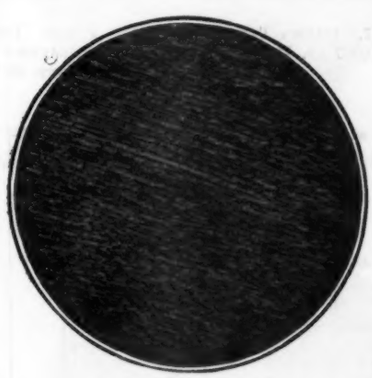


FIG. 5. SWAGED TUNGSTEN ROD. 0.030 IN. DIAM. × 152.

MANUFACTURE OF WROUGHT AND DUCTILE TUNGSTEN.

Up to about ten years ago, it had not been possible mechanically to work tungsten. About the year 1908, Dr. William D. Coolidge, of the General Electric Company, produced ductile tungsten from what was then supposed to be an inherently brittle metal and which, in fact, was inherently brittle in its normal state, that is when composed of equiaxed grains. Since that time many products, chief among which are the filaments for electric incandescent lamps, have been made from wrought and ductile tungsten.

Tungsten is produced chiefly from the minerals wolframite, and sheelite (1–8). The ores may be refined in many ways. For example, the ore may be fused with alkali carbonates and the fusion dissolved in water; sodium tungstate is formed, which is soluble in water. This may be changed to tungstic oxide WO_3, by the addition of an acid to the sodium tungstate liquor. WO_3, a yellow precipitate, is separated by filtering. The tungsten oxide may then be purified to any desired degree by dissolving it in ammonia and then reprecipitating by the addition of acid, followed by filtering and washing.

For the manufacture of most of the wrought tungsten products, the tungsten oxide is treated as follows: After drying, sufficient thorium nitrate solution is added to make 0·75 per cent. thoria (ThO_2) in the oxide. The tungsten oxide is made into a batter with the thorium nitrate solution, additional water being added if necessary, after which it is thoroughly mixed. The mixture is then dried and placed in either a fireclay or a silica crucible and heated to about 1,100 deg. C. for a period usually in excess of 1 hour. This is called the firing operation, and it has for its purpose the agglomerating of the extremely fine particles of tungsten oxide into larger, or coarser-grained particles. When the firing is done in a fireclay crucible, some of the crucible material is dissolved by the oxide, and produces a beneficial effect when the metal is to be used for incandescent lamp filaments.

The fired oxide is then reduced by hydrogen to tungsten metal powder, at a temperature in the neighbourhood of 1,000 deg. C. The tungsten powder thus produced is relatively coarse-grained when compared to the tungsten powder from which the sintered tungsten filaments were made before the advent of drawn tungsten wire.

The tungsten powder is pressed dry, into any desirable shape or size. A common size and shape consists of a rod about 16 in. (40 cm.) long having a cross-section about $\frac{1}{4}$ in. (9·5 mm.) square. The pressure on such a rod must be applied from the side of the mould and not from the end, else the resulting tungsten ingot will not be workable. The pressed tungsten slug is so fragile that it can be moved only by sliding it along a surface. It is moved in this manner on to a platform of tungsten, nickel, or other suitable material having a high melting-point, and while still on the platform is inserted into an electric furnace of the tube type, which is heated to about 1,200 deg. to 1,300 deg. C., in which an atmosphere of hydrogen is maintained. This is called the baking operation. After baking, the tungsten slug may be handled without danger of breaking. At this stage, it is porous, containing about 40 per cent. voids.

The baked tungsten slug is then clamped into two electrodes, arranged in a vertical position, the bottom one of which floats in a bath of mercury cooled by a water jacket. This arrangement is necessary, because in the operations which follow, the tungsten slug shrinks, usually about 15 per cent. in length, and the mercury well must accommodate this shrinkage and still maintain electrical contact with the lower electrode. After the slug is securely clamped in the electrodes, a gastight housing is lowered around it and a current of hydrogen is passed through this housing. Electric current is then passed through the slug, thus heating it to an extremely high temperature. For most purposes, a temperature of about 3,000 deg. to 3,200 deg. C. is used, and this temperature is maintained for 10 minutes or 15 minutes. This may be called the sintering operation.

The sintered tungsten ingot is substantially free from voids, having a density of about 18. The two ends which were clamped in the electrodes will not have been heated to a sufficiently high temperature to cause sintering, so they are broken off and then the ingot is ready for the mechanical working process.

The working operation is begun in swaging machines (10–16), which operate the swaging dies. A pair of swaging dies consists of two similar blocks of high-speed steel, each block containing half the desired opening. The openings are circular in cross-section. The side of the steel block containing half the desired opening is called its "face." These two half-dies are placed in the swaging machine face to face, sufficiently loose so that the swaging blow can be struck, when the die halves move away from and toward each other. The machine head rotates and the dies rotate with it. Centrifugal force moves the die halves apart and rollers in the head of the machine push them together again. The dies move backward and forward several thousand times per minute. The faces of these dies must be made in a special manner for the swaging of tungsten. The portions which come in contact with the metal to be worked must be very much shorter than when swaging the ordinary metals. These are called short-faced dies. They are made of high-speed steel because they are to be used to swage hot metal.

For beginning the swaging operation on a tungsten ingot having a square or rectangular cross-section, a pair of swaging dies is selected which will just round off the corners of the ingot. The ingot is put into an electric furnace, usually consisting of an alundum tube wound with tungsten or molybdenum wire, in which an atmosphere of hydrogen is maintained. The temperature of this furnace may be as high as 1,700 deg. C., but it is more frequently in the neighbourhood of 1,600 deg. C. When the ingot has attained the temperature of the furnace, one end is grasped with a pair of tongs and the other end is quickly inserted into the swaging machine. It is not possible to swage the whole length of the rod in this manner, so the ends of the rod are reversed and it is again heated, after which the unswaged end is inserted into the swaging machine. A pair of swaging dies having a somewhat smaller opening than the first pair of dies used is now put into the machine; the ingot is heated again and the swaging operations continued as before. Four or five dies are required to make a round rod from a square or rectangular ingot.

When the tungsten rod is sufficiently elongated to enable the end which first passes through the swaging machine to be gripped from the exit side, only one heating for each pair of swaging dies is necessary. As the degree of work increases on the rod, the temperature is gradually decreased. When the working temperature has been reduced to about 1,300 deg. C., gas may be used to heat the metal preparatory to swaging. The temperature may be decreased in steps, that is, there may be a certain temperature maintained for half-dozen or more dies and then the temperature lowered for the next half-dozen dies. These conditions will depend on the properties desired in the swaged tungsten rod. The swaging operation may begin on tungsten ingots of any size, but a common size is $\frac{1}{4}$ in. to $\frac{1}{2}$ in. square (6·35 mm. to 9·5 mm.), and 12 in. to 14 in. long (30·48 cm. to 35·56 cm.).

If it is desired to produce wrought tungsten rods more than 0·030 in. (0·76 mm.) diameter, all of the work is done by swaging. If, however, it is desired to produce tungsten wires smaller than 0·030 in. diameter, the swaging operation is resorted to only until a size of 0·030 in. or thereabouts is reached. The temperature of swaging will have been reduced as the size of the rod decreased so that the 0·030 in. rod would be swaged at a temperature of 1,000 deg. or 1,100 deg. C.

When the tungsten ingot is removed from the furnace

* Paper submitted for discussion by the American Institute of Mining engineers.

† Director of Research, Aluminium Castings Company.

(1–8) References are to bibliography at end of paper.

previous to swaging, the temperature corresponds to a brilliant white heat. Tungsten oxide has not formed in the furnace because of the hydrogen atmosphere, but as soon as the ingot is removed from the hydrogen atmosphere, its temperature is such that tungsten oxide forms very rapidly, volatilises and condenses as a white fume at some distance above the rod itself.

The tungsten ingots may also be reduced by rolling. High-speed rolls are employed and the ingot is heated to 1,500 deg. C. before each pass. Rolls are used for flat pieces and swaging machines for round sections.

The sintered tungsten ingot is as brittle as glass and extremely fragile. It is composed of equiaxed grains such as may be seen in Fig. 1, page 239, representing the structure of a sintered tungsten ingot. When the swaging has been continued until the rectangular cross-section of the ingot has been changed to circular, the structure has been changed to that shown in Fig. 2. With still further swaging, when the tungsten rod has reached a diameter of 0·125 in. (3·2 mm.), its structure is changed to that shown in Fig. 3. At a size of 0·082 in. (2·08 mm.) its structure has changed to one corresponding to that shown in Fig. 4, while Fig. 5 represents the structure when the tungsten rod has been swaged to a diameter of 0·030 in. (0·76 mm.).

It will be seen from these micrographs that the equiaxed grains composing the sintered tungsten ingot have been progressively elongated during the swaging operations into fibres of metallic tungsten. The 0·030-in. swaged rod shown in Fig. 5 is ductile cold. It can be bent cold or it can be drawn cold.

While the tensile strength of the sintered tungsten ingot from which this 0·030-in. swaged tungsten rod was reduced was only 18,000 lb. per square inch, the tensile strength of the rod was 215,000 lb. per square inch.

The sintered tungsten ingot was absolutely brittle, but the 0·030-in. swaged tungsten rod has an elongation of about 4 per cent. in 2 in. and a reduction in area at the point of fracture of about 28 per cent.

When it is desired to produce wires smaller than 0·030 in. diameter, a hot drawing process is resorted to. Diamond dies are usually employed for this purpose. The lubrication used, both for the swaging operations on the smaller rods and in the drawing process, is aquadag. The wire to be drawn is first passed through an aquadag mixture which is in the form of a thin paste, and then through a gas flame or other heating medium which heats the wire to the desired drawing temperature and also bakes on it a coating of the lubricant. The dies vary in size by small steps; that is, the diameter of the opening in one die will be only about 6 per cent. greater than that in the next following die.

The temperature at the beginning of the drawing may be in the neighbourhood of 1,000 deg. C. and when the wire is reduced to the size of about 0·005 in. (0·127 mm.) diameter, the temperature of drawing will have been reduced to a dull red heat. Fig. 6 is a micrograph of a drawn tungsten wire. All of the tungsten wires so produced, no matter what their size, are ductile cold. The increase in tensile strength is continuous, the smallest wires being the strongest.

Table I shows the increase in tensile strength of tungsten products with the increase in mechanical working. Tungsten wire 1·14 mils diameter (a mil is 0·001 in.) shows a reduction of area at the point of fracture of about 65 per cent. Coupled with great strength, drawn tungsten wire possesses the property of ductility in the cold to a very usable degree. The wire can be coiled on mandrels having diameters but slightly greater than that of the wire itself. It can be bent into the various shapes necessary for lamp making, and it can be handled in long lengths without danger of breaking.

Table I shows that the tensile strength of the 1·14-mil drawn wire is about 33 times as great as that of the sintered tungsten ingot. In ordinary metal-working processes, an increase of tensile strength of six times that of the original starting material is unusual.

General Relationship between Tungsten and other Metals.

It should be noted from the preceding that tungsten possesses several properties different from those of the common ductile metals. For example, when the common ductile metals are worked cold or at elevated temperatures below their annealing temperatures, they are rendered more brittle at room temperature. Tungsten cannot be worked at room temperature when it is composed of equiaxed grains. When it is worked at elevated temperatures below its equiaxing temperature in such a manner as permanently to deform the grains, its ductility at room temperature increases.

When the ductile metals which have been made brittle by mechanical working at room temperature or at elevated temperatures below their annealing temperatures, are annealed, ductility is restored. When tungsten which has been made ductile by mechanical working at an elevated temperature below its equiaxing temperature is heated above the equiaxing temperature, its ductility at room temperature is lost.

The ductile metals are in their most ductile condition when they are composed of small equiaxed grains. Tungsten is in its most brittle condition when it is composed of small equiaxed grains.

When the ductile metals are heated in such a manner that coarse-grained structures are produced, they become less malleable and ductile at room temperature, as a result of the coarse-grained structures. When tungsten, however, is heated in such a manner as to produce extremely coarse-grained structures, the resulting tungsten product possesses, to a slight degree, the ability to be deformed, especially by pressure at room temperature. The utility of this type of deformability in tungsten is limited. Let us suppose, for the sake of argument, that we have a single grain of tungsten, and that we proceed mechanically to work this grain at room temperature. It becomes harder and more brittle, due to the strain hardening, and our first thought would be to heat it above its equiaxing temperature, so that it would regain its malleability and ductility. Above the equiaxing temperature this strain-hardened grain would form many equiaxed grains. We would have produced in this manner a piece of tungsten metal composed of small equiaxed grains. This material would be absolutely brittle at room temperature and no further working at room temperature would be possible. This piece of tungsten could, however, be mechanically worked at high temperatures by the processes described above.

Molybdenum has some properties similar to those of tungsten, and others similar to those of the common ductile metals. It is in a more ductile condition at room temperature when it is composed of fine grains than when composed of coarse grains. In this respect it is similar to the common ductile metals. When its grains are deformed by mechanical working at temperatures above room temperature and below its equiaxing temperature, its ductility at room temperature increases. In this respect it more nearly resembles tungsten.

Tantalum (35) resembles the common ductile metals in all of its working properties. Tantalum must be very pure and especially free from hydrogen or nitrogen to be in a ductile condition. When it is melted in a vacuum, it is found to be one of the most malleable and ductile of metals. Fig. 7 is a micrograph of a cold-drawn tantalum wire which was mechanically worked at room temperature, without any annealing, from a fused globule of tantalum to a wire 0·007 in. (0·177 mm.) in diameter. This wire has not even yet reached its maximum limit of cold working. Fig. 8 shows a piece of the same wire which was heated in a vacuum to 1,600 deg. C. for 5 minutes. It will be noted that recrystallisation has taken place. This annealed wire is much more ductile than the cold-worked wire, thus showing that in these respects tantalum is similar to the common ductile metals. Fig. 9 is a micrograph of a piece of the same tantalum wire heated for 1 minute, in an atmosphere of hydrogen, to 1,600 deg. C. Recrystallisation has taken place, but this wire has absorbed enough hydrogen to make it extremely brittle and fragile at room temperature. The properties of tungsten wire are the same whether heated in a vacuum or in hydrogen.

Cast zinc or worked zinc made coarse grained by a high temperature anneal may be brittle at room temperature and workable at 150 deg. C., and after this working the ductility at room temperature will be greater than before working. It is now known that this increase in ductility of zinc is due to a substitution of a fine-grained structure for the coarse-grained one. It is known that 150 deg. C. is above the annealing temperature of worked zinc and consequently in the hot-working region. The refinement of the grain in zinc by working at 100 deg.

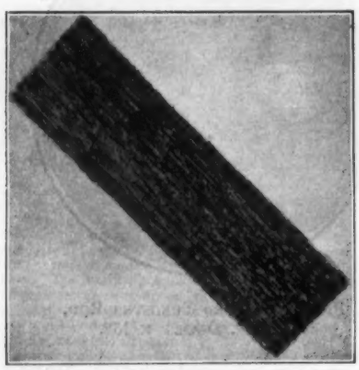


Fig. 6. Drawn Tungsten Wire, 0.010 In. Diam. × 169.

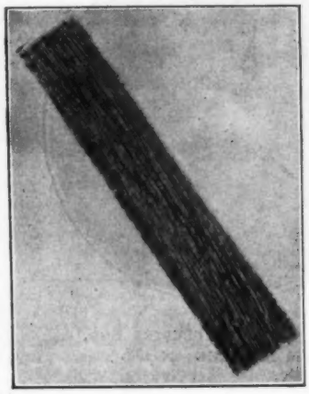


Fig. 7. Drawn Tantalum Wire, 0.007 In. Diam. × 125.

Fig. 8. Tantalum Wire Annealed 5 Min. at 1600 Deg. Cent. in Vacuum. × 125.

Fig. 9. Tantalum Wire Annealed 1 Min. in Hydrogen Atmosphere to 1600 Deg. Cent. × 125.

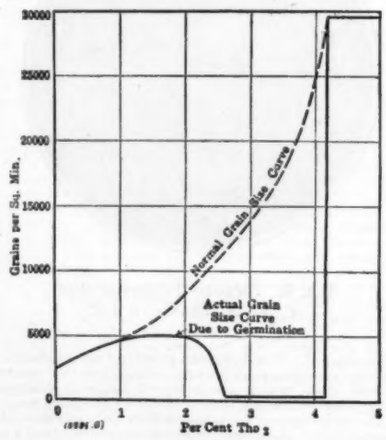


Diagram A. Variation in Grain Size of Tungsten Ingots with Variation in Thoria. Heated 12 Min. to Mean Temperature of 3200 Deg. Cent.

Table I.—*Tensile Strength of Tungsten.*

Kind of Material.	Diameter in Mils.	Tensile Strength in Lb. per Sq. In.
Sintered tungsten ingot	200 by 250	18,000
Swaged rod	216·0	50,600
Swaged rod	125·0	107,000
Swaged rod	80·0	176,600
Swaged rod	26·0	215,000
Drawn wire	18·0	264,000
Drawn wire	7·23	340,000
Drawn wire	5·78	366,000
Drawn wire	5·50	378,000
Drawn wire	3·96	483,000
Drawn wire	1·14	590,000

to 150 deg. C. is analogous to the breaking down of the coarse grains in a steel ingot by working above a red heat(36). No amount of work on tungsten above its annealing temperature will make it ductile at room temperature.

Platinum may be produced in a coherent malleable and ductile form by the Wolloston process(37) without resorting to the fusion operation. There are several points of difference between the Wolloston method for producing coherent ductile platinum without fusion and the method of producing coherent ductile tungsten without fusion. The platinum has only to be made coherent and it is inherently ductile. Tungsten has to be made coherent and then ductilised by the working process. The platinum cake immediately before working contains about 40 per cent. voids and these are welded by the working. The voids must be eliminated in tungsten before the working begins, else the material will not be workable.

Effect of Thoria on the Structure of Sintered Tungsten Ingots.

The principal need for thoria or other non-metallic substances in tungsten which is to be used for lamp filaments is to control the direction, and, to a certain extent, the degree of grain growth, in the filament in such a manner as to render them both rugged (not easily broken by rough handling of the lamps) and free from off-setting.* With the old type of pressed tungsten filament, the purity of the tungsten did not have to be considered except for the functioning of the tungsten wire as a lamp filament. By the present method of manufacture of lamp filaments, however, the sintered tungsten ingots must be capable of being mechanically worked hot. Therefore the addition of thoria or other non-metallic substance must be made judiciously and the heat treatment of the tungsten ingot must also be varied to suit the thoria content. Tungsten containing more than 2 per cent. thoria is difficult to work into small wires.

The effect of the thoria is to increase the resistance to grain growth at high temperatures. Other non-metallic substances will offer resistance to grain growth in proportion to the volume, arrangement and size of globules in the metal. It is difficult, however, to retain the more volatile oxides in the ingot. Even silica vaporises almost completely during the sintering operation. Alumina volatilises more slowly and thoria very little.

Diagram A shows the variation in grain size of tungsten ingot with variation on the quantity of thoria, the temperature being maintained constant at about 3,200 deg. C. and the time constant—12 minutes. It would seem as if the resistance to grain growth had decreased in the region between 2·5 per cent. and 4 per cent. thoria. This apparent decrease in resistance to grain growth is readily explained by the germinative temperature laws (17–26). The increase in resistance to grain growth is continuous with increase in the amount of thoria, according to the dotted portions of the curve shown in Diagram A. The germinative conditions have not produced exaggerated growth of grain up to about 1·5 per cent thoria, nor above about 4·5 per cent. thoria, so that the normal curve representing equilibrium grain size for the given time and temperature conditions would be independent of the exaggerated grain growth portion. These changes in grain size due to variation in the quantity of thoria can be seen plainly in the

* Off-setting is the transverse displacement of a section of the filament wire. The displacement occurs at places where a grain boundary occupies the whole cross-section of the wire.

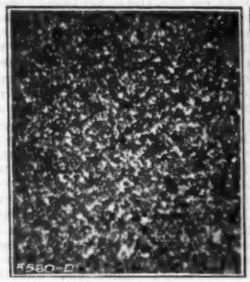


FIG. 10. CONTAINING 1 PER CENT. ThO_2.

FIG. 11. CONTAINING 2 PER CENT. ThO_2.

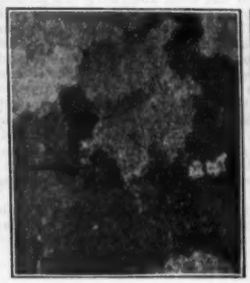


FIG. 12. CONTAINING 3 PER CENT. ThO_2.

FIG. 13. CONTAINING 4 PER CENT. ThO_2.

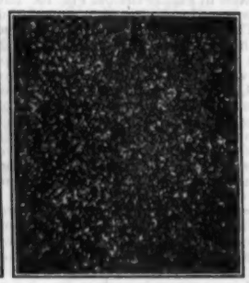


FIG. 14. CONTAINING 5 PER CENT. ThO_2.

FIGS. 10 TO 14. TUNGSTEN INGOTS HEATED 12 MIN. AT 3200 DEG. CENT. × 16.

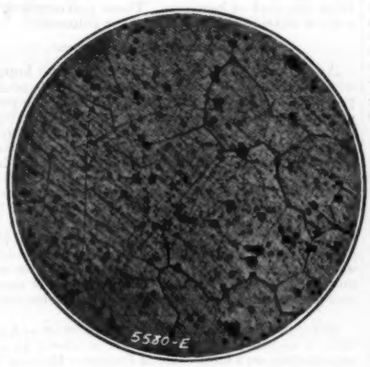


FIG. 15. CONTAINING 1 PER CENT. ThO_2.

FIG. 16. CONTAINING 2 PER CENT. ThO_2.

FIG. 17. CONTAINING 3 PER CENT. ThO_2.

FIG. 18. CONTAINING 4 PER CENT. ThO_2.

FIG. 19. CONTAINING 5 PER CENT. ThO_2.

FIG. 20. TUNGSTEN INGOT SHOWING TWO LARGE GRAINS IN POSITION TO ABSORB SMALL GRAINS. × 117.

FIGS. 15 TO 19. TUNGSTEN INGOTS HEATED 12 MIN. AT 3200 DEG. CENT. × 389.

micrographs. Figs. 10, 11, 12, 13 and 14 are micrographs of the tungsten ingots containing respectively 1 per cent., 2 per cent., 3 per cent., 4 per cent. and 5 per cent. thoria. The ingots were all sintered at 3,200 deg. C. for 12 minutes. Figs. 15, 16, 17, 18 and 19 are micrographs of the same samples containing 1 per cent., 2 per cent., 3 per cent., 4 per cent. and 5 per cent. thoria respectively, at a higher magnification. The micrographs at the higher magnification show very plainly not only the quantity of thoria, but its distribution. The thoria is present in small spherical globules in all of the samples, The number of globules is much greater in Fig. 19 than in Fig. 15. The size of the globules, however, does not vary in a marked degree.

The explanation for these coarse-grained structures with increase in resistance to grain growth is as follows: Let us take, for example, the sample containing 3 per cent. thoria. When it was heated to a mean temperature of 3,200 deg. C. by the passage of an electric current in an atmosphere of hydrogen, the axis of the comparatively long tungsten ingot would be its hottest portion. A temperature gradient would obtain from the axis to the surface of the ingot. With 1 per cent. thoria present, even the surface of the ingot, when heated to a mean temperature of 3,200 deg. C. would permit the free growth of adjacent grains. With 3 per cent. thoria, however, the resistance to grain growth will have been sufficiently increased so that the portion of the tungsten ingot near the surface will be below the temperature of free grain growth. The portions nearer the axis, being hotter, will permit grain growth to take place. There will be a sharp boundary line between that portion of the ingot in which grain growth could take place and that portion in which growth was not possible (or at least could take place but slowly) under the existing conditions. The grains in the growth range will be larger than those in the inert range. At the boundary between the growth and inert grains, the former, because of their larger size, will be able to absorb the latter, which cannot coalesce with one another because they are (1) too nearly the same size, and (2) too cold. Adjacent grains in the growth range away from the boundary between the growth and inert grains, cannot coalesce freely with one another because they are too nearly the same size. Their size, however, is considerably greater than that of the grains in the inert region. The grains at the boundary between the inert and growth regions become germinant grains. They increase their size by absorption of the inert grains until they are much larger than the hotter grains in the growth region, which they then absorb. The resulting structure will be an extremely coarse-grained one, with a general tendency for the grains to be radial, much as if the ingot had solidified in a mould from the molten condition.

In the sample containing 2·5 per cent. thoria, germinant grains were formed first at a lower temperature, because the resistance to grain growth would be less with 2·5 per cent. than with 3 per cent. thoria. With the same average temperature, the germinant grains in the 2·5 per cent. thoria sample would first form nearer the surface of the sample. This is exactly what was observed. With the sample containing 4 per cent. thoria, the germinant grains would first form in a hotter portion of the ingot. It was observed that the germinant grains did form initially in the 4 per cent. thoria ingot practically at its axis. This indicates that with the 4 per cent. thoria ingot at a mean temperature of 3,200 deg. C. the region of free grain growth occurs only in the hottest portion of the ingot and all other parts of the ingot are in the inert range. With 5 per cent. thoria, no part of the ingot is sufficiently hot with a mean temperature of 3,200 deg. C. for free grain growth to take place in a time period of 12 minutes, so the whole cross-section of the ingot is in the inert range. The samples containing 1 per cent. and 2 per cent. thoria, at a mean temperature of 3,200 deg. C. were sufficiently hot for the whole cross-sections to be above their germinative temperatures, that is, to be entirely within the growth range. It will be noted that the 2 per cent. thoria sample is finer grained than the 1 per cent. sample and the sample containing 5 per cent. thoria is the finest grained of them all. It will be noted also in these samples that, where grain growth has taken place, the thoria globules have not apparently changed in position. For example, in Fig. 17 a portion of one grain only is shown. The thoria globules, however, are distributed within this grain in a manner very similar to the distribution of the thoria globules in Fig. 19, which consists of a fine-grained structure with the thoria globules largely situated at the boundaries of the small grains.

Some calculations indicate that the difference in temperature between the surface of the tungsten ingot ¼ in. (6·35 mm.) square and its axis is about 150 deg. C. when a mean temperature of 3,200 deg. C. is maintained by the passage of electric current through the ingot.

By heating these samples for various time periods, the history of grain growth can be studied. In the growth range, an apparent equilibrium grain size is reached within a few minutes at a high temperature, say, 3,200 deg. C. At lower temperatures around 2,600 deg. and 2,700 deg. C. a longer time is needed in order to produce an apparent equilibrium grain size. Under germinative conditions, if the germinative temperature is high, the velocity of grain growth is rapid, and if the germinative temperature is low, the velocity of grain growth is slow. At a temperature of 2,600 deg. C. the rate of grain growth was only about one-twentieth of the rate at 3,200 deg. C.

The sintering together of the individual particles of tungsten, or their welding, is an entirely distinct operation from their coalescence. At a temperature of about 2,400 deg. or 2,500 deg. C., sintering takes place and is complete within a few minutes. Most of the voids have been closed and most of the shrinkage of the ingot takes place during the sintering. With increase in temperature these small grains formed by the sintering operation commence their growth. If no germinative temperature condition is encountered, the grains will increase in size with increase in temperature, and, up to a certain point, with increase in time of exposure. Germinative conditions, however, may change the order of grain size enormously.

When the germinative temperature is maintained at a point about midway between the axis and the surface of an ingot, the large germinant grains grow both toward the surface, absorbing the inert grains, and toward the axis, absorbing the grains which are in approximate equilibrium with each other. At the boundary lines between two large germinant grains and a fine-grained region, there will always be, if the fine-grained region is considered as a sea and the coarse-grained region as land, a bay at the intersection of the two large grains with the fine-grained region. This indicates that the two large grains may be competing for the small grains at this point. The forces of attack will act in different directions and a sort of neutral zone in which grain growth is less rapid than normal will obtain. Fig. 20 shows this phenomenon.

Tungsten ingots made up of an aggregate of large and small grains are not easily worked. They are apt to crack at low temperatures along the grain boundaries, between the large grains or at boundaries between large and small-grained areas.

(To be continued.)

Netherlands India.—The preliminaries in connection with the Engineering Congress that is to be held, in the interests of the Netherlands East Indies, at Batavia, in 1919, are already in progress, according to *The London and China Telegraph*. The Congress will probably be divided into six different sections: (1) Harbours and means of communication (railways, tramways, telegraphy and telephony); (2) irrigation, drainage, waterworks, etc.; (3) roads and bridges, town planning, architecture, etc.; (4) production of energy, electricity, and industries; (5) mining and geology; (6) miscellaneous. The participants in the Congress will comprise the experts from the surrounding colonies and also from the neighbouring countries, such as Western America, Japan, Australia, and South Africa.

Universal Directory of Railway Officials, 1918.—We have received a copy of this directory for 1918, the twenty-fourth year of publication; it is compiled by Mr. S. R. Blundstone, editor of *The Railway Engineer*, and is issued by the Directory Publishing Company, Limited, 15, Farringdon-avenue, E.C. 4. The subscription price is 10*s.*, and after June 1 15*s.* It opens with an alphabetical index to countries, and one to names of railways, tramways (British) and railway institutions. These are followed by information on the railways, which includes the length open, gauge, number of rolling-stock, names of officials, &c. Similar particulars are given for colonial, continental, American and other foreign railways. The book also gives an index of 160 pages arranged alphabetically of the names of the railway officials, both British and foreign, and one of manufacturers and suppliers of railway plant and material, machinery, stores and appliances, arranged alphabetically according to specialities.

Synthetic Hydrocarbons.—Some new patented processes of the Badische Anilin- und Sodafabrik hardly look promising. Starting from hydrogen and carbon monoxide (or dioxide), they obtain at high pressures (100 atmospheres and more) and temperatures of 300 deg. C. or 400 deg. C. some hydrocarbons boiling at 250 deg. C., which are condensed or absorbed. The presence of catalysts is essential, and they use for this purpose asbestos impregnated with caustic soda and the oxide of osmium or chromium. As the reactions yield some water and carbon dioxide, however, while some carbon is deposited, and as methane is also formed, it is evidently difficult to control the reaction in such a way as to secure valuable products. When the original mixture contains W_2 (instead of W), the yield of hydrocarbons is smaller than in the former case. Nitrogenous organic compounds have also been prepared by similar high-pressure and high-temperature reactions in the presence of nitrogen. In some cases the catalyst should possess high thermal conductivity. Wire gauge, and especially also the carbides of the metals of the iron group have given good results.

American Mining Terms.—The Abstracts of Current Decisions on Mines and Mining reported from September to December, 1917, recently issued by the Bureau of Mines, Washington, give the following interpretation of several American mining terms:—Drummy, a term applied to loose coal or rock in a mine, that produces a hollow sound when tapped with any hard substance. Gobbing slate, a term applied where a layer of slate is found between two veins of coal and the lower vein is mined out, and the upper vein and the slate are shot down, the coal loaded out and then the slate moved to one side out of the way. Miner's weight, used in coal mining lease, is the basis for a price per ton to be paid for mining; is a varying quantity of mine-run material, and in such quantity as operators and miners may agree upon as necessary or sufficient to produce a ton of prepared coal. Parting slate, a thin or varying layer of slate between two seams of coal. Slue is a term used by miners meaning to straighten a coal-cutting machine. In cutting coal the machine moves from right to left and the back part of the machine moves faster than the front, it being necessary at intervals to stop the machine and straighten or "slue" it.

CATALOGUE.

Electro-deposited Copper.—The enormous increase in chemical apparatus in this country for the manufacture both of dyes and explosives has directed increased attention to electro-deposited copper for linings and coverings of other metals. At the Standard Plating and "Kupron" Works, 62–68, Rosebery-avenue, London, we have recently seen a large steel vessel, or autoclave, some 3 ft. 6 in. in diameter and 5 ft. long, plated entirely inside with copper about ¼ in. in thickness, thus giving it the chemical qualities of a copper vessel with the strength of a steel one, the latter being necessary to withstand the very high pressures to which it will be subjected. The makers guarantee that the deposit is as absolutely dense and homogeneous throughout as rolled copper. In a catalogue we have received from the firm there are illustrations of very complicated curved copper pipes, with numerous branches and flanges, made entirely by electro-deposition on cores which are afterwards removed by melting. These pipes are integral, without joints either welded or brazed. By the same process copper can be deposited on hydraulic rams or cylinders, up to ½ in. thick, or on to tail shafts or tubes. Of course, there is nothing new in electroplating with copper, but hitherto it has been almost impossible to get deposits of such thickness and of perfect homogeneity. Kupronising, as the process is called, finds its chief field in artistic and architectural work. It is used to cover steel casemate bars with copper, and also steel tubes for handrails. Wood handrails, mouldings, pilasters and capitals can be impregnated to render them rot-proof, and then covered with ¹/₁₆ in. of copper, which encloses them like a fly in amber. If the colour, of the copper does not harmonise with the surroundings a very thin coating of gun-metal, or of brass, can be deposited over it, and this can be polished, or be treated with any of the chemicals used for bronzes. Memorial tablets prepared by sculptors in clay or wax can be reproduced in metal of substantial thickness at one tithe the cost of castings. These matters are, however a little outside the scope of these columns.

Ammonium Nitrate.—A battery of 100 koppers coke ovens with a total consumption of 1,900 tons of coal per day, is calculated to provide 7,000 tons per annum of ammonium nitrate, says the *Iron Age*. With electric energy at 5 mils. per kilowatt-hour and ammonia at 13 cents per lb., the ammonium nitrate can be made at less than half the price the Government is now paying.

The Royal Petroleum Company, Amsterdam.—This company, which is paying 48 per cent. for last year, against 38 per cent. for the previous year, is about to double its ordinary share capital, at present 85,520,000 gulden, each shareholder, for every two old shares, obtaining one free share and the right to subscribe another new share at par. The company is very active, and is extending its establishments in various directions.

Electric Salt Extraction in Norway.—A company with a capital of 20,000,000 kr. is about to start the exploitation on a large scale of Professor Helland Hansen's method for extracting salt from sea-water, and the undertaking is being backed up by several men of exceptional standing. It will in all probability be found expedient to erect several works along the coast, as more electric energy becomes available. The comparatively large capital is principally necessary on account of the large plant needed, pumping stations, &c., absorbing the bulk of the power; the production of the salt itself only requires a small amount of energy, and is consequently cheap. As to the location of the new factories, no definite decision has been arrived at, but Stavanger has been mentioned as a likely place for the first factory, and the Glaamfjord for the second.

High-speed Steel.—The metallurgical treatment of high-speed steel was recently discussed by Mr. J. L. Thorne before the Steel Treating Research Society of Detroit, says *The Iron Age*. He warned the purchaser against buying steels by trade name only, since there have been instances where the composition has been materially changed without notice to the user. The high-speed steels on the market now are comprised within the following limits, the last column giving a good chemical specification:—

		Range, Per cent.	Proposed, Per cent.
Carbon	...	0.47 to 0.91	0.65
Silicon	...	0.12 to 5.00	0.12
Manganese	...	0.12 to 0.67	0.25
Sulphur	...	0.008 to 0.057	0.02
Phosphorus	...	0.006 to 0.051	0.02
Chromium	...	1.50 to 5.52	3.50
Vanadium	...	0.13 to 2.50	1.00
Tungsten	...	11.74 to 22.27	18.00

After the tool has been formed and sent to the hardening room it should first be given a "soaking" heat at from 1,500 to 1,800 deg. Fahr. When uniformly heated, it is transferred to a high-temperature furnace, whose heat is as uniform as possible, controlled with standardised pyrometers and allowed to remain there a certain specified time. At the proper instant, the tool is removed and quenched, preferably in oil circulated over cooling coils to maintain a uniform low temperature. The quenching temperature must be far above the critical temperature, approaching that where the tool actually softens. The hardened tool is then "drawn" in a low temperature furnace, care being taken that the metal progressively softens up to a point lying between 700 deg. F. and 800 deg. F., from which to about 1,100 degrees it increases in hardness with the temperature.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

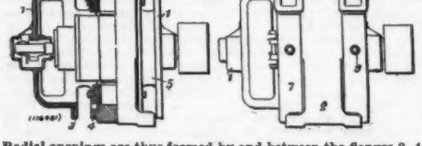
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

ELECTRICAL APPARATUS.

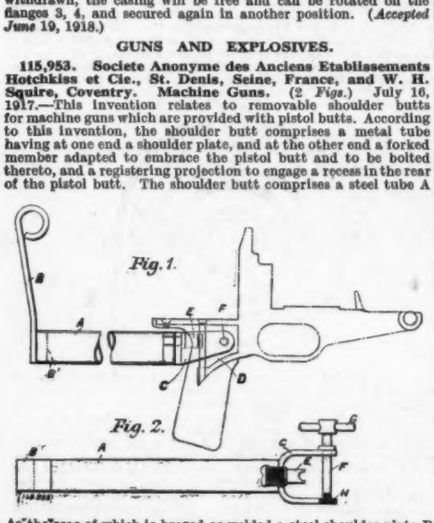
116,481. J. W. Burleigh, Burnham. Dynamo Electric Machines. (4 *Figs.*) June 29, 1917.—This invention relates to dynamo electric machinery of the totally-enclosed type provided with heat-dissipating means. According to this invention, the heat-dissipating means is or are carried by a casing or casings that is or are adjustable around the machine with the object of facilitating the fixing of the machine in various locations. 1, 1, are the two end-bearing brackets. They are provided at the parts which come against and adjacent the yoke 2 with two parallel radial flanges 3, 4, that are spaced apart, and are united around a portion or portions of their peripheries by webs 5.



Radial openings are thus formed by and between the flanges 3, 4, and the ends of the webs 5. 7 is a band of metal which encircles the flanges 3, 4, and is seated thereon, thereby forming a casing. The casings are each provided with a port 8 (or with ports) and to the ports 8 heat-dissipating means (not shown) of any suitable construction is attached. The casings 7 are adjustably mounted on the flanges 3, 4, and bolts 9 are passed through the casings 7 into the webs 5. It will be understood that if a bolt 9 be withdrawn, the casing will be free and can be rotated on the flanges 3, 4, and secured again in another position. (*Accepted June 19, 1918.*)

GUNS AND EXPLOSIVES.

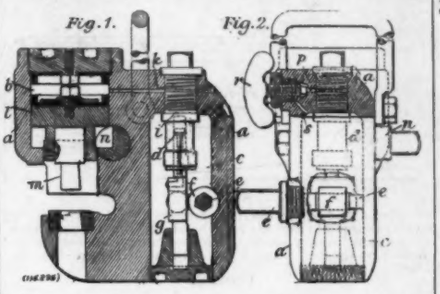
115,953. Societe Anonyme des Anciens Etablissements Hotchkiss et Cie., St. Denis, Seine, France, and W. H. Squire, Coventry. Machine Guns. (2 *Figs.*) July 16, 1917.—This invention relates to removable shoulder butts for machine guns which are provided with pistol butts. According to this invention, the shoulder butt comprises a metal tube having at one end a shoulder plate, and at the other end a forked member adapted to embrace the pistol butt and to be bolted thereto, and a registering projection to engage a recess in the rear of the pistol butt. The shoulder butt comprises a steel tube A



to the rear of which is brazed or welded a steel shoulder plate B provided with a boss B1 which enters the end of the tube. To the forward end of the tube is similarly connected a forked member C, which may be a forging. One limb of the forked member passes on each side of the pistol butt D of the gun, and a registering projection or lug E screwed into the member C engages a recess in the rear of the pistol butt D. The forked member C is firmly clamped to the pistol butt D by a bolt F provided with a cross-head G. The bolt F passes through a plain hole in one limb of the fork and in the butt D, and screws into a tapped hole H in the other limb of the fork. (*Sealed.*)

HYDRAULIC MACHINERY.

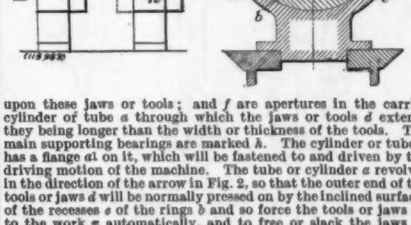
116,236. Tangyes, Limited, Smethwick, and E. Johnson, Smethwick. Hydraulic Punches. (3 *Figs.*) January 11, 1918.—The invention consists of improvements in hydraulic punches of the kind technically known as "self-contained hydraulic bears." According to the invention, the body of the bear is so constructed that the water containing cylinder or reservoir in which the pump is arranged and the hydraulic cylinder in which the ram works are situated side by side or one behind the other, and preferably with their axes parallel or nearly parallel. *a* is the body of the bear having therein the hydraulic cylinder *b* and the water reservoir *c*. The pump *d*, which is worked by an external arm or lever (not shown) fitted on the square end of the spindle *e*, as is usual, is arranged in the water containing cylinder *c* with the pump barrel at the top of the cylinder *c* instead of at the bottom as in the ordinary punching bear. The spindle *e* has on an inner part of an angular figure in cross-section the short arm *f* of the operating lever, the end of which short arm *f* engages in a slot in the pump rod *g* as in the ordinary punching bear. The axial hole *i* in the pump barrel *d* opens into a horizontal passage *k* through which the water passes on the working of the pump into the hydraulic cylinder *b*, thereby giving motion to the ram *l* and punch *m* secured thereto. After the operation of the punch *m* the hydraulic ram *l* is lifted by the turning of the cam *n* as is usual, the water being returned from



the hydraulic cylinder *b* through the horizontal passage *k*, side hole *p*, which is opened by the partial turning of the screw plug *r*, and inclined way or passage *s* (see Fig. 2). (*Accepted June 12, 1918.*)

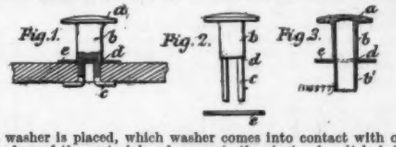
MACHINE AND OTHER TOOLS, SHAFTING, &c.

115,983. S. Schofield and J. A. Wright, Southport. Chucks. (2 *Figs.*) August 10, 1917.—This invention has reference to chucks. *a* represents a tubular or cylindrical work carrier part, having within it "work" *x*; and *b* are angularly-recessed rings within which the work carrier *a* works and by which it is carried, the said recess lying between the outer part of the rings and the outer surface of the cylinder or tube *a*. *c* are other angle shaped rings, one flange or part of which *c*1, lies within the angular recesses of the rings *b*; *d* are "work" engaging or gripping jaws or tools, which fit and work in radial apertures in the flanges *c*1 of the rings *c*; *e* are inclined curved parts against which the outer ends of the jaw or tools *d* lie, and which operate



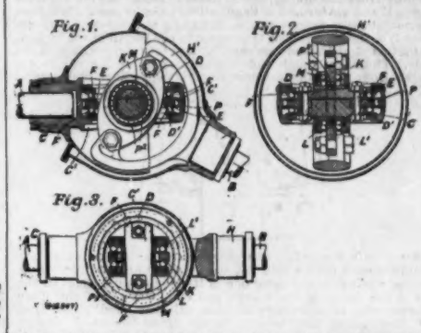
upon these jaws or tools; and *f* are apertures in the carrier cylinder or tube *a* through which the jaws or tools *d* extend, they being longer than the width or thickness of the tools. The main supporting bearings are marked *h*. The cylinder or tube *a* has a flange *a*1 on it, which will be fastened to and driven by the driving motion of the machine. The tube or cylinder *a* revolves in the direction of the arrow in Fig. 2, so that the outer end of the tools or jaws *d* will be normally pressed on by the inclined surfaces of the recesses *e* of the rings *b* and so force the tools or jaws on to the work *x* automatically, and to free or slack the jaws or tools on the work, the rings *c* are moved in the opposite direction to the arrow, they being so moved by inserting a podger or tool in holes at the periphery of the rings *c*. (*Sealed.*)

116,377. The Bifurcated and Tubular Rivet Company, Limited, London and Aylesbury, and H. J. Joscelyne, Aylesbury. Bifurcated or Tubular Rivets. (5 *Figs.*) June 25, 1917.—This invention relates to tubular or bifurcated rivets having a shank with substantially parallel walls. The improved rivets have a shoulder which is produced according to the present invention by reducing the thickness of the rivet shank on its outside from the point of the shoulder to the extremity, the bore of the rivet being uniform throughout its length. In the case of a bifurcated rivet the thickness of the prongs is reduced, that is to say, an outer shoulder is formed at the junction of the prongs and the shank of the rivet. On the reduced tubular end or prongs and abutting against the shoulder,



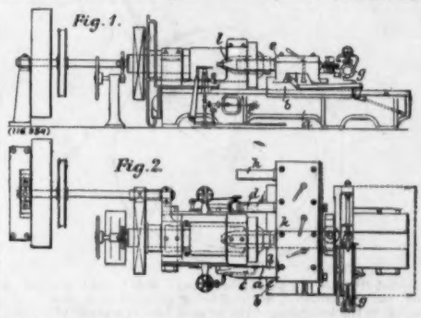
a washer is placed, which washer comes into contact with one surface of the material and prevents the rivet, when it is being clinched from being forced further in than the limit of such washer permits, hence a portion of the shank and the head will stand out beyond the surface of the material. In Figs. 1 and 2, *a* is the head, which may be of any shape, and *b* the shank, the line of demarcation between the latter and the usual prongs *c* being the shoulder *d*, formed as stated, while *e* is the washer, which is capable of being passed over the prong portion of the rivet until it abuts against the shoulder. In Fig. 1 the washer is shown in position on one side of the material *f*, the prongs as clenched on the other side. In Fig. 3 the tubular shank is reduced at the shoulder *d*, the end *b*1 opposite to the head having thinner walls, which facilitates the clenching. (*Accepted June 19, 1918.*)

116,247. E. M. Munro, London. Universal Joints. (3 *Figs.*) March 12, 1918.—This invention relates to universal joints. A joint, according to the present invention, comprises two annular members provided with two sets of friction balls or rollers, one set taking mainly lateral thrust and the other mainly journal thrust. The shafts to be coupled by the joint are shown at A and B. To the shaft A is fitted a socket C forming part of a housing C1 containing two outer ball-race discs D, D1, and an inner thrust plate E. Balls F are placed between the members D, E and D1, E, in the manner usual in a thrust ball bearing. The shaft B is fitted with a socket H forming part of a yoke H1 connected to a plate K, which is the thrust plate of another ball bearing at right angles to the bearings formed by the parts D, D1, E and F. The balls F1 of this second ball bearing work between the thrust plate K and ball race rings L and L1. These rings are mounted on a flange sleeve M. The two sets of ball bearings are placed so as to transmit lateral thrust, but, according to the present invention, to provide for the transmission of very heavy loads with the shafts inclined at a considerable angle to each other friction members are provided to take journal thrust.



These additional members are in the form of two sets of roller bearings. One of these comprises a number of rollers P which work between the slightly recessed outer surface of the thrust plate E and a running surface on the inside of the housing C1. The other set of journal bearings comprises rollers P2 operating between the slightly recessed surface of the sleeve and the inside surface of the thrust plate K. (*Accepted June 12, 1918.*)

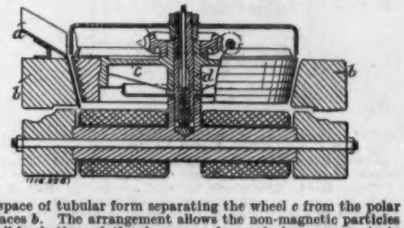
116,354. W. L. Philip, Melksham. A Metal-Boring Machine. (2 *Figs.*) June 8, 1917.—The invention consists in a metal-boring machine comprising a cross slide for holding one or more boring tools and fitted with hydraulic or other fluid pressure operating gear and also with mechanical feed. In carrying the invention into effect, when producing a machine for boring and finishing the interior of shells, there is provided upon the bed *a* a saddle *b* with longitudinal high-pressure hydraulic feed *c* towards the running head and low-pressure return *d*, and



in this saddle is fitted a cross-slide *e* having hydraulic traverse feed motion *g* and carrying preferably four boring bars *h*, *i*, *k*, *l*, one for rough boring the parallel portion of bore, one for finishing same, one for roughing the curved nose portion of bore, and one for finishing the curved portion. The hydraulic cross-motion of the cross-slide is high pressure in both directions exhausting direct and preferably has a multiplying gear by means of racks and pinions or other devices in order to obviate the necessity of fitting a long cylinder, and at the same time giving rapid change of bars. (*Accepted June 19, 1918.*)

MINING, METALLURGY AND METAL-WORKING.

116,228. Fraser and Chalmers, Limited, Erith, and W. Bullock, Bexley. Ore-Separating Machines. (4 *Figs.*) December 29, 1917.—This invention relates to apparatus for the separation according to their magnetic permeability of ores or other materials or mixtures suitably crushed and in either a dry or wet state. The apparatus is of the type in which the separation is effected by passing the materials or mixtures through the air space separating a wheel formed of a substance having magnetic permeability from the pole faces of an electromagnet. According to the invention, the material of which the magnetic components are to be separated from the non-magnetic is delivered from suitably-placed hoppers *a* to the upper end of a vertical or inclined

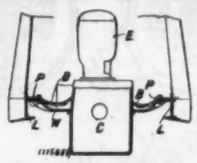


air space of tubular form separating the wheel *c* from the polar surfaces *b*. The arrangement allows the non-magnetic particles to fall freely through the air space and a much cleaner concentrate is obtained than if the material is delivered to the surface of the wheel and carried round to the air gap, in which case some proportion of the non-magnetic particles are mechanically held and prevented from falling by the presence of the adjacent magnetic particles. In a preferred form, the wheel, which is formed as a frustum of a cone, revolves between the similarly inclined faces of the pole pieces *b*, about a fixed central pin *d*, which can be raised or lowered in order to adjust the air gap between the revolving wheel and the pole faces. (*Accepted June 12, 1918.*)

MOTOR ROAD VEHICLES.

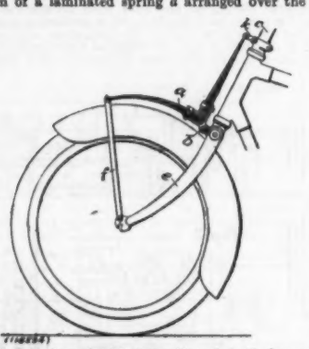
115,883. G. Roesch and Clement Talbot, Limited, London. Engine Suspension Devices. (3 *Figs.*) May 10, 1917.—This invention has for object to provide a strong and simple connection between the engine and the forward end of the chassis longitudinals which will give the necessary flexibility

to permit of slight oscillations of the engine and the two longitudinals each in relation to the others. The characteristics of the present invention are a longitudinal and corrugated trough in the crank-case and a thin steel plate combined with it in the manner hereinafter exemplified. Wings W project at each side horizontally from the upper part of the crank-case casting C of the engine E and are formed as longitudinal troughs having marginal horizontal outer flanges and each having also upward corrugations B of the trough floor transverse to the length of the trough, and situated at its ends and also at a point intermediate of the ends. Thus the trough and the upper part of the crank-case derive from the corrugations ample longitudinal and lateral



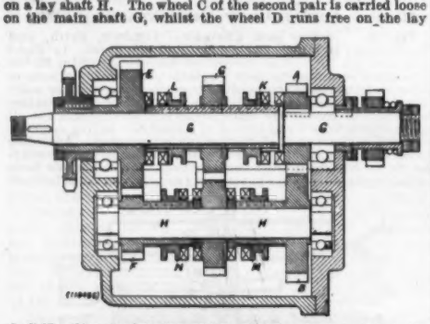
stiffness and strength. The outer margins of the wings are combined each with a thin flat steel plate P appropriated to it, the plate being bolted along one of its longitudinal edges to the top of the flange of the trough and extended across the space between that trough-flange and the adjacent longitudinal L of the chassis, and there secured to the upper face of the latter. The steel plate P is preferably provided along its outer longitudinal edge with an unturned flange to take on its exterior the bottom margin of the bonnet. The plate P constitutes a flexible joint between the rigid trough W and the adjacent portion of the chassis longitudinal L, and the plate P and the trough W together fill up the space between the outside of the crank casing C and the aforesaid longitudinals L. (*Sealed.*)

116,234. F. E. Baker and T. J. Biggs, King's Norton, Birmingham. Motor Cycles. (4 *Figs.*) January 9, 1917.—This invention provides improved spring mounting for the front wheels of motor cycles. The present invention comprises the combination of a laminated spring *a* arranged over the wheel



rim and attached at a point *b* between its ends to the lower end of the steering column *c*, one end being attached to a strut *f* connected to the lower end of the pivoted fork *e*, and the other end either likewise connected to the lower end of the fork or connected by a link *k* to the upper end of the steering column. (*Accepted June* 12, 1918.)

116,456. B. A. Malkin, Leith. Variable-Speed Gear. (1 *Fig.*) November 8, 1917.—This invention relates to change-speed gear of the type in which four forward speeds are obtained by three pairs of wheels arranged on two shafts. In carrying out this invention, the gear consists of three pairs—A, B; C, D; and E, F—of gear wheels. The wheel A of the first pair is fast on the main shaft G, whilst the wheel B is loosely mounted on a lay shaft H. The wheel C of the second pair is carried loose on the main shaft G, whilst the wheel D runs free on the lay



shaft H. The wheel E of the third pair is loosely mounted on the main shaft G, whilst the wheel F runs free on the lay shaft H. The wheel C is not directly connected to the wheels A, E, but by means of dog clutches K, L, it can be connected to either or both of these wheels. The wheels B, D, F, on the lay shaft H can rotate independently of each other, but the wheel D can be connected by dog clutches M, N, to either or both of the wheels B, F. Friction clutches may be substituted for the dog clutches. (*Accepted June* 19, 1918.)

116,383. S. H. Cope, and The Wariand Dual Rim Company, Limited, Aston, Birmingham. Road Vehicle Wheels. (6 *Figs.*) June 29, 1917.—This invention relates to road vehicle wheels of the detachable-rim type. The invention comprises a rim which is divided transversely so that over a short length of the circumference the adjacent ends overlap laterally, and a lever which engages one end and takes its fulcrum on the other so that one of the said ends can be sprung under the other and the rim caused to assume a helical form. A light steel rim *a* adapted to engage the beaded edges of an ordinary pneumatic tyre cover is divided by a transverse incision *b* which is partly at right angles to the parallel sides or edges of the rim and partly inclined thereto. A hooked or claw-like lever *c* has a part *d* placed against the outer side of the part *e* of the rim and a part *f* placed against the inner side of the part *g* of the rim. With the part *e* acting as fulcrum an inward radial pressure towards the centre of the rim applied to the outer end of the lever enables the rim ends to be separated radially and displaced laterally to an extent which enables the part *e* to spring outwards and abut against the part *g*, as shown in Fig. 2. For convenience in

Fig. 1.

Fig. 2.

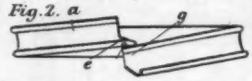
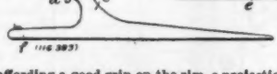


Fig. 3.



affording a good grip on the rim, a projection on the part *e* of the lever is arranged to engage a small hole in the rim. A projection on the part *f* simply serves to localise the pressure exerted on the rim by the part *f*, and is not essential. (*Accepted June* 19, 1918.)

PUMPS.

115,919. H. A. Fleuss, Thatcham. Pumps. (3 *Figs.*) June 5, 1917.—This invention relates to pumps for exhausting air and gases, of the cylinder and piston type. According to this invention, the piston *b* is operated by a piston rod *b*² which passes through a stuffing-box *c*¹ in the pump valve *c*, and has upon it, above the cylinder cover, a slide *e* for actuating a ram *g* for supplying oil to the cylinder close to the under side of the pump valve *c*. The slide and mechanism for actuating the ram, together with the top of the cylinder, are surrounded by a casing from which the air is exhausted by another pump. The ram *g*¹ for pumping the oil works in a cylinder *g*² having ports leading into another cylinder *h* surrounding the first and containing oil, the ports being opened and closed by the ram. Attached to the

Fig. 1.

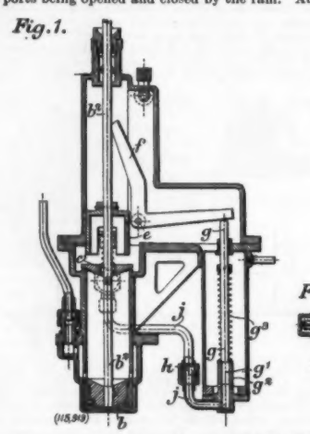
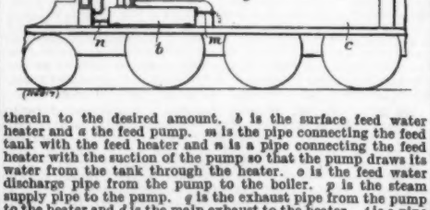


Fig. 2.

ram *g*¹ is a stem *g* which may be in two parts abutting one another endwise, and which has a spring *g*³ tending to hold the ram in such a position that the ports are open. The ram is reciprocated in the cylinder by means of a bell crank lever *f*, which engages with the stem and is actuated by the slide *e* on the piston rod, the parts being so adjusted that the oil is pumped into the cylinder as the piston nears the pump valve. In the passage *j* between the ram cylinder and the pump cylinder is a non-return valve *k*, and the oil passes into the pump cylinder through another valve controlled by a spring which is powerful enough to hold it upon its seat if the vacuum in the apparatus is broken. The oil cylinder is fitted with filling and levelling plugs. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

116,017. G. and J. Weir, Limited, Cathcart, Glasgow, and J. G. Latta, Cathcart, Glasgow. Locomotives. (1 *Fig.*) October 15, 1917.—This invention relates to the heating of feed water on steam locomotives and its delivery by a feed pump into the boiler. The present invention consists in putting and maintaining the feed tank of the locomotive under super-atmospheric pressure by forcing air into it and in placing a surface feed water heater between the feed tank and the feed pump, *i.e.*, on the discharge side of the tank and the suction side of the pump. *c* is the feed tank, which is closed and which is stayed to withstand pressure. *e* is a steam jet injector by which air is forced into the feed tank to raise and maintain the pressure



therein to the desired amount. *b* is the surface feed water heater and *a* the feed pump. *m* is the pipe connecting the feed tank with the feed heater and *n* is a pipe connecting the feed heater with the suction of the pump so that the pump draws its water from the tank through the heater. *o* is the feed water discharge pipe from the pump to the boiler. *p* is the steam supply pipe to the pump. *q* is the exhaust pipe from the pump to the heater and *d* is the main exhaust to the heater. *i* is a pipe connection to convey live steam to the injector, and *h* is a pipe connection to convey exhaust steam to the same. *v* is a valve which allows either live steam or exhaust steam to be supplied at will to the injector. *u* is a safety valve provided on the feed tank to prevent pressure therein rising to a dangerous degree (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

115,958. J. Thomson, Edinburgh. Steam Generators. (5 *Figs.*) July 20, 1917.—This invention relates to water-tube steam generators of the type in which steam is generated by spraying water, under pressure, into heated tubes, through detachable nozzles at their ends. The generator consists, as usual, of a number of steam generating tubes 1 connected to headers 8, 9. The lower end of each front header 8 is connected to a transverse water drum 10, whilst the upper end is sealed. The upper end of each rear or back header 9 is, as usual, connected directly, or indirectly, to a steam-receiving drum 13, whilst the lower ends are connected to a drainage drum 14, said drum being in communication with the transverse water drum 10 so that water accumulating in the former beyond a predetermined amount can,

Fig. 1.

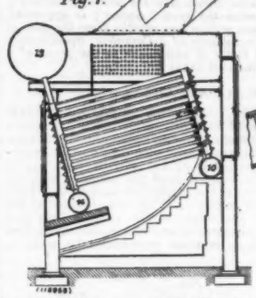
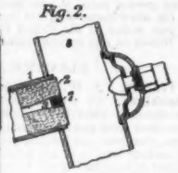
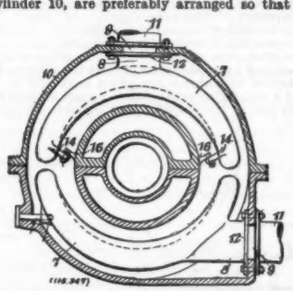


Fig. 2.



by means of a pump, or the like, be transferred to the latter. The feed water is projected into the tubes 1 through nozzles 2 at their ends in the form of a spray, and for this purpose the feed water in the water drum and front headers must always be under a pressure in excess of the steam pressure in the steam drum. According to this invention, the nozzles are positioned at the upper end of each inclined tube 1 so that the spray issuing therefrom is not subjected to any drowning or choking effect from surrounding water, and the tubes are so disposed that their inlet ends are on a higher level than their outlet ends, so that any unevaporated water will be automatically drained off. Each nozzle or plug 2 is provided with a tapped or screwed hole 3 so that it can, when desired, be readily withdrawn by means of a drawbolt. (*Accepted June* 5, 1918.)

116,347. K. Baumann, Barnfield, Urmston. Steam Turbines. (6 *Figs.*) June 7, 1917.—This invention relates to removable nozzle boxes employed in steam turbines for admitting steam to the first row of moving blades. The nozzle-box 7 is formed as a curved hollow chamber closed at its ends and having a steam inlet 8 located at an intermediate point along its length. The inlet 8 is provided with a flange 12 by means of which the nozzle-box 7 is secured within the cylinder 10, in such a position that the inlet registers with a steam admission port 9 in the side of the turbine cylinder 10, and a steam supply pipe 11. The bolts, by means of which the flange 12 is attached to the turbine cylinder 10, are preferably arranged so that the joint

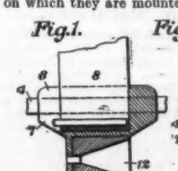


between the inlet 8 of the nozzle-box and the turbine cylinder 10 can be tightened from the exterior of the turbine cylinder. Guides for maintaining the nozzle-box 7 in its position within the turbine cylinder with respect to the moving blades are provided at either end of the nozzle-box 7, each comprising a lug 14 on the nozzle-box furnished with a pin adapted to slide within a projection 16 on the turbine cylinder. The nozzle-box 7 in the lower half of the drawing is similar to the nozzle-box located in the upper half of the turbine cylinder, except that the inlet 8 is placed nearer one end of the box than the other in order that the admission port 9 and steampipe 11 may be located in a convenient part of the turbine cylinder. (*Accepted June* 19, 1918.)

TEXTILE MACHINERY.

116,058. A. Newton-Smith, Westminster. Pickers. (4 *Figs.*) February 20, 1918.—This invention has relation to pickers for looms and has reference to pickers that are mounted and slide to and fro' in the shuttle-box on races that comprise rails or grooves with which parts of the pickers are formed to engage. Such a mode of mounting the picker is herein spoken of as a two-point mounting. Pickers in accordance with this invention have the picking strap 8 attached thereto between the parts 4, 5, on which they are mounted and so that the picking

Fig. 1.



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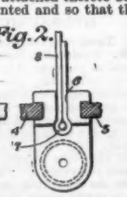

effort is applied as nearly as possible in line with the shuttle; the attachment is effected by forming the picker at its upper part between its points of support with a longitudinal slot 6, the lower end of which opens into a recess or cavity 7 shorter than the picker and situated above the shuttle buffer 12, folding a portion of the picker strap 8 back on itself, passing the bight through the slot into the recess or cavity 7, and securing it therein by passing a pin or peg 8 endwise into the bight. (*Sealed.*)